

**NASA TECHNICAL
MEMORANDUM**

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(NASA-TM-X-71700) BIBLIOGRAPHY ON
CONTAMINANTS AND SOLUBILITY OF ORGANIC
COMPOUNDS IN OXYGEN (NASA) 190 p HC \$7.00
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**BIBLIOGRAPHY ON CONTAMINANTS AND SOLUBILITY
OF ORGANIC COMPOUNDS IN OXYGEN**

Compiled by Paul M. Ordin
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FOREWORD

The Aerospace Safety Research and Data Institute (ASRDI) was established to support NASA, its contractors, and the aerospace community with technical information and consultation on safety problems. In the process of gathering, evaluating, and applying safety-related information, gaps in the existing safety technology are often noted. Where it appears that progress in filling such gaps can be made through research, ASRDI may undertake or sponsor it. ASRDI also operates a Safety Data Bank of technical information which includes computer files of specialized information sources (organizations) and safety specialists. Current activities are concentrated in the safety implications associated with fire and explosion, cryogenic systems, propellants and other hazardous materials, structural failure, fragmentation, and aircraft systems and operations.

Solomon Weiss, Acting Director
Aerospace Safety Research and Data Institute
National Aeronautics and Space Administration

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INTRODUCTION

A part of the NASA Aerospace Safety Research and Data Institute's (ASRDI) mission is to compile and store in a computerized system bibliographic citations on hazards and safety in various areas related to aerospace activities. One of these areas is Cryogenic Fluids Safety. At the present time the computerized data bank contains about 6500 bibliographic citations on the subject.

Each citation in the data bank contains many items of information about the document. Some of the items are title, author, abstract, corporate source, description of figures pertinent to hazards or safety, key references, and descriptors (keywords) by which the document can be retrieved. In addition, each citation includes an evaluation of the technical contents as to being good/excellent, acceptable or poor. The descriptors used to define the contents of the documents and subsequently used in the computerized search operations were developed for the Cryogenic Fluid Safety by experts in the cryogenics field.

This report is a compilation of a number of document citations, from the Data Bank as of December 1974, which contain information on contaminants in oxygen. A major ASRDI effort has been a review of oxygen safety and a number of special publications summarizing the current state of the art have been published. These include Thermophysical Properties (ref. 1), Temperature Measurements (ref. 2), Flow Measurement Instrumentation (ref. 3), Heat Transfer and Fluid Dynamics (ref. 4), Density and Liquid Level (ref. 5), Characteristics of Metals that Influence Safety (ref. 6), Cleaning Requirements (ref. 7), and Oxygen Systems Engineering Review (ref. 8). Other reports dealing with oxygen safety and research of oxygen systems have also been published (refs. 9 and 10).

The search of the ASRDI Data Bank for information on contaminants in oxygen was initiated after an analysis of liquid remaining after the boil-off of liquid oxygen from a long term oxygen storage tank indicated the presence of aromatic hydrocarbons. Due to the reactivity characteristics of oxygen and possible sources of ignition of contaminants, extensive cleanliness requirements have been utilized (ref. 7). The contaminants, recognized as hazards in oxygen, are identified in most cleanliness requirements as particulate matter, fibers, condensible hydrocarbons, solvent soluble organic residues and solids, and do not usually include considerations of the wide range of organic compounds.

The citations included in the report are present under three separate subject headings:

I. CONTAMINANTS AND SOLUBILITY OF ORGANIC COMPOUNDS IN
OXYGEN

II. REACTION CHARACTERISTICS OF ORGANIC COMPOUNDS WITH
OXYGEN

III. SAMPLING AND DETECTION LIMITS OF IMPURITIES

In a number of cases, the same citation is referred to in several subject categories.

The report contains, in addition to the citations, an author index and an index of major descriptors. Specific chemical compounds referred to in the citations are also listed in the index.

**I. CONTAMINANTS AND SOLUBILITY OF
ORGANIC COMPOUNDS IN OXYGEN**

CONTAMINANTS IN LIQUID OXYGEN AS RELATED TO SAFETY IN
LIQUID OXYGEN PRODUCTION AND DISTRIBUTION EQUIPMENT

by

ARRICK, C.D.

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-ABSTRACT-

CONTAMINANTS IN LIQUID OXYGEN ARE CLASSED AS VOLATILES, NON-VOLATILES, AND ACETYLENIC, THE LATTER BEING THE CLASS WITH THE GREATEST HAZARD. THIS CLASS HAS LOW SOLUBILITY IN LOX AND THEREFORE PRECIPITATES OUT AS A SOLID. IF SUITABLE PRECAUTIONS ARE NOT TAKEN, THESE SOLIDS CAN ACCUMULATE TO DANGEROUS LEVELS IN AIR SEPARATION PLANT EQUIPMENT. THIS DISCUSSION IS LIMITED TO THE CONTAMINANTS INTRODUCED FROM THE AIR PROCESSED IN AIR SEPARATION PLANTS. THE MOST HAZARDOUS AREA IN THE PLANT IS THE MAIN CONDENSER, THE DESIGN OF WHICH SHOULD PREVENT LOCAL ACCUMULATIONS OF SOLIDS. THE SAME IS TRUE OF LIQUID PIPING IN THE PLANT. THERE MUST BE NO TRAPPED POCKETS WHERE LIQUID MAY BOIL AND NON-VOLATILE HYDROCARBONS CONCENTRATE. IN DISTRIBUTION EQUIPMENT, LIQUID OXYGEN IN THE TANK IS NOT PERMITTED TO BOIL OFF TO DRYNESS, VAPORIZERS ARE OPERATED WITH LARGE TEMPERATURE DIFFERENCES TO AVOID DEPOSITION OF SOLID COMBUSTIBLES ON HEAT TRANSFER SURFACES.

-PERTINENT FIGURES-

FIG. 1 MAJOR TYPES OF MAIN CONDENSERS IN LIQUID OXYGEN PLANTS, PAGE 223// TAB. 1 CLASSIFICATION OF HYDROCARBONS, PAGE 219//TAB. 2 HYDROCARBONS IN ATMOSPHERIC AIR AT PLANT SITES, PAGE 220//TAB. 3 HYDROCARBONS IN LIQUID OXYGEN, PAGE 221.

-SOURCE INFORMATION-

CORPORATE SOURCE -

LINDE CO., TONAWANDA, N.Y.

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STUDY OF LIQUID OXYGEN CONTAMINATION. PROGRESS REPT. NO. 2

by

BAILEY, B.M.
VIGNALE, V.J.

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-ABSTRACT-

THE OBJECT OF THIS PROGRAM IS THE RECOMMENDATION OF REALISTIC SPECIFICATIONS FOR PROCUREMENT AND USE OF LIQUID OXYGEN FOR ROCKET PROPELLANT SUPPLY SYSTEMS, INCLUDING STANDARDS FOR CLEANLINESS, MONITORING FOR CLEANLINESS AND CONTAMINANTS, AND RECOMMENDATIONS OF DESIGN CRITERIA FOR REDUCTION OF CONTAMINANTS AND INCREASED SAFETY. THIS PROGRESS REPORT DISCUSSES THE SIGNIFICANCE AND SOURCES OF CONTAMINANTS AND THE CHANGES IN QUALITY OF LIQUID OXYGEN IN TRANSIT BETWEEN AIR-SEPARATION PLANT STORAGE AND LOADING AND UNLOADING THE MISSILE. SOME RECOMMENDATIONS ARE MADE CONCERNING LIQUID TRANSFER PROCEDURE, PIPING ARRANGEMENTS, AND MEANS FOR REMOVAL OF LOW-SOLUBILITY CONTAMINANTS FROM STORED LIQUID OXYGEN.

-PERTINENT FIGURES-

FIG.1 SIMPLIFIED DIAGRAM, MISSILE OXYGEN SUPPLY AND LOADING SYSTEM, PAGE 12 // FIG.2 DIFFERENTIAL EVAPORATION OF 99.5 PERCENT LIQUID OXYGEN, PAGE 14 // FIG.3 TYPICAL LAUNCH-SITE LIQUID OXYGEN STORAGE AND LOADING SYSTEM, PAGE 17 // FIG.4 EXAMPLES OF PIPING DETAILS RESULTING IN CONTAMINANT CONCENTRATION BUILD-UP, PAGE 19 // FIG.5 LAUNCH-SITE LIQUID OXYGEN STORAGE FLOW LINES, PAGE 21 // FIG.6 EFFECT OF VENT VELOCITY AND ATMOSPHERIC DIFFUSION ON OXYGEN CONCENTRATION IN THE VENT LINE - SCHEMATIC, PAGE 23 // FIG.7 PLANT LIQUID OXYGEN STORAGE TANK - SCHEMATIC, PAGE 26 // FIG.8 CONTAMINATION CONCENTRATION AS A FUNCTION OF ADSORPTION-PURIFICATION TIME FOR TWO TYPES OF FLOW THROUGH THE STORAGE VESSEL AND THREE RELATIVE PUMPING CAPACITIES, PAGE 33 // FIG.9 A PROPOSED LIQUID OXYGEN STORAGE TANK ARRANGEMENT FOR MAXIMUM FLUSHING ACTION BY THROUGH-FLOW, PAGE 35 // FIG.10 AN ARRANGEMENT FOR TRANSFER CONNECTIONS WITH REDUCED CONTAMINANT ADDITION, PAGE 40

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CONTRACT AF 33(616-6730, OCTOBER 1959// (MAJ.) J. C. LESHER AND C.
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HAZARD LEVEL OF HYDROCARBON FILMS IN SYSTEMS CONTAINING LIQUID AND GASEOUS OXYGEN

by

KEHAF, E.

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-ABSTRACT-

THE OBJECT OF THIS WORK WAS TO DETERMINE REALISTIC STANDARDS OF CLEANLINESS IN SYSTEMS CONTAINING LIQUID AND GASEOUS OXYGEN. AN ARBITRARY FIGURE OF 4 MILLIGRAMS PER SQUARE FOOT HAD BEEN PREVIOUSLY SET BY EXAMINATION OF SYSTEMS THAT HAD CAUSED NO TROUBLE IN THE PAST. IT WAS FELT THAT THIS FIGURE WAS TOO LOW AND THAT EXPERIMENTAL DETERMINATION OF THE SAFE LEVEL SHOULD BE MADE TO SET SUCH STANDARDS. BASED ON THE EXPERIMENTS REPORTED HERE, THE RECOMMENDED SAFE LEVEL CONTAMINATION WITH HYDROCARBONS WITH VISCOSITY AND VAPOR PRESSURE SIMILAR TO HEXADECANE IS 100 MILLIGRAMS PER SQUARE FOOT.

-PERTINENT FIGURES-

FIG. 1 IGNITION APPARATUS USING GASEOUS OXYGEN PAGE 163//FIG. 2 IGNITION APPARATUS USING LIQUID OXYGEN PAGE 164//FIG. 3 IGNITION APPARATUS USING GASEOUS OXYGEN PAGE 164//FIG. 4 IGNITION APPARATUS USING LIQUID OXYGEN BEFORE IGNITION PAGE 165//FIG. 5 IGNITION APPARATUS USING LIQUID OXYGEN AFTER IGNITION PAGE 166//FIG. 6 UNBURNED HEXADECANE FILMS AFTER SPARK IGNITION IN GASEOUS OXYGEN PAGE 166

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J.C. LESUER, AFMND/MTOTP AND C.L. WILLIAMS, STL/PTD, DRAFT OF INTERIOR STANDARDS FOR LOX SYSTEMS, MAY 8, 1959//K.N. PALMER, J. INST. FUEL 29, P. 293 (1956)//I.B. BASVNOV AND V.G. MIKHEDOV, KISLOFOD 12, NO. 5, P. 1 (1959). TRANSLATION NO. RD-2220 BY ASSOCIATED TECHNICAL SERVICES, INC.//AIR PRODUCTS, INCORPORATED, UNPUBLISHED WORK//H. BERGER, FEWERSCHUTZECH 21, P. 15 (1941)//D.B. SPALDING, GAS TURBINES - VOL. 2. SOME FUNDAMENTALS OF COMBUSTION. BUTTERWORTHS SCIENTIFIC PUBLICATIONS, LONDON (1955)

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JOURNAL PROCEEDINGS -
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CRYOG. ENG. CONF., 7TH, ANN ARBOR, MICH., AUG 15-7, 1961)
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COMPATIBILITY OF LUBRICANTS WITH MISSILE FUELS AND
OXIDIZERS

by

FISCH, K.R.
PEALE, L.
MESSINA, J.
GISSER, H.

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-ABSTRACT-

VARIOUS COMPOUNDS WERE STUDIED TO DETERMINE THEIR SUITABILITY AS LUBRICANTS IN THE PRESENCE OF FUELS AND OXIDIZERS USED IN MISSILE SYSTEMS. THE CLASSES OF COMPOUNDS STUDIED WERE THE HALOGENATED ALIPHATIC AND AROMATIC HYDROCARBONS, THE SILICON AND PERFLUOROCOMPOUNDS, ESTERS, ETHERS, AND COMPOUNDS CONTAINING NITROGEN. THE FUELS AND OXIDIZERS INCLUDED ETHYL ALCOHOL, HYDROCARBON FUEL, UNSYMMETRICAL DIMETHYLDIAZINE, DIETHYLENETRIAMINE, A MIXTURE OF THE LATTER TWO, HYDROGEN PEROXIDE, INHIBITED RED FUMING NITRIC ACID, AND LIQUID OXYGEN. THE MOST PROMISING COMPOUNDS WERE STUDIED FOR THEIR EXTREME PRESSURE, ANTIWEAR, VOLATILITY, AND VISCOMETRIC PROPERTIES. THREE COMPOUNDS WERE FOUND TO BE COMPLETELY INERT (UNREACTIVE AND INSOLUBLE) WITH ALL THE FUELS AND OXIDIZERS. ONE WAS A LIQUID (PERFLUOROTRIBUTYLAMINE) AND THE OTHER TWO WERE SOLIDS (POLYTETRAFLUOROETHYLENE AND TETRAFLUOROETHYLENE-HEXAFLUOROPROPYLENE COPOLYMER). THE PERFLUOROTRIBUTYLAMINE EXHIBITED ADEQUATE LUBRICATION PROPERTIES EXCEPT FOR EXCESSIVE VOLATILITY. THE PREPARATION OF HIGHER HOMOLOGS OF THIS COMPOUND IS EXPECTED TO REMEDY THIS SHORTCOMING. THE POLYTETRAFLUOROETHYLENE AND THE COPOLYMER MAY FIND APPLICATION AS COMPONENTS OF A GREASE-TYPE LUBRICANT.

-PERTINENT FIGURES-

TAB.1 MISSILE LUBRICANTS PAGE 287//TAB.2 SOLUBILITY AND REACTIVITY OF HALOGENATED ALIPHATIC HYDROCARBONS PAGE 289//TAB.3 SOLUBILITY AND REACTIVITY OF SILICON COMPOUNDS PAGE 290//TAB.4 SOLUBILITY AND REACTIVITY OF ESTERS PAGE 291//TAB.5 SOLUBILITY AND REACTIVITY OF HALOGENATED AND NONHALOGENATED AROMATIC HYDROCARBONS PAGE 291//TAB.6 SOLUBILITY AND REACTIVITY OF ETHERS PAGE 292//TAB.7 SOLUBILITY AND REACTIVITY OF NITROGEN COMPOUNDS PAGE 292//TAB.8 SOLUBILITY AND REACTIVITY OF PERFLUORO COMPOUNDS PAGE 293//TAB.9 LOX IMPACT SENSITIVITY TESTS PAGE 293//TAB.10 VISCOSITY OF TEST FLUIDS PAGE 294//TAB.11 WEAR AND EP PROPERTIES OF TEST FLUIDS

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NONMETALLIC MATERIALS LAB. // FRANKFORD ARSENAL, PHILADELPHIA, PA.

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ASLE TRANS. VOL 5, 287-96 (1962). PRESENTED AT ANNUAL MEETING OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS, ST. LOUIS, MO., MAY 1962.

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CONTAMINATION OF MISSILE FLUID SYSTEMS.

by

PECKHAM, P.M.

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-ABSTRACT-

THE AEROSPACE INDUSTRY IS UNIQUE IN ITS STRINGENT REQUIREMENTS REGARDING CONTAMINATION CONTROL. THE REPORT COVERS PROCEDURES, SPECIFICATIONS, ETC. ESTABLISHED BY THE MARTIN COMPANY OVER A NUMBER OF YEARS IN THIS AREA. SPECIFIC AREAS COVERED IN DETAIL DEAL WITH DESIGN RECOMMENDATIONS, MANUFACTURING CONTROLS, CLEANING PROCEDURES AND PROCUREMENT RESTRICTIONS (MARTIN HAS ESTABLISHED A CONTAMINATION CONTROLLED PARTS LIST). TABLES ARE PRESENTED SHOWING: ALLOWED CONTAMINANTS IN LIQUID AND GASEOUS OXYGEN AND NITROGEN, RP-1 AND GASEOUS HELIUM. TABLES ARE ALSO GIVEN SHOWING THE ALLOWED CONTAMINANTS IN SOLVENT RINSES AND VACUUMING PROCEDURES. THE CONTAMINANTS SPECIFICALLY COVERED IN THE VARIOUS PROCEDURES AND SPECIFICATIONS ARE HYDROCARBONS (SPECIFICALLY ACETYLENE), FILTERABLE SOLIDS (FILTER SCREEN SIZES ARE GIVEN) AND WATER CONTENT.

-PERTINENT FIGURES-

FIG. 1 AEROQUIP SELF-SEALING COUPLING -- EXTERNAL VIEW, PAGE 30//FIG. 2 AEROQUIP SELF-SEALING COUPLING -- CUTAWAY VIEW, PAGE 31//FIG. 3 HYDROSTATIC TEST FIXTURE -- GENERAL VIEW, PAGE 35//FIG. 4 MISSILE TANK CLEANING CELL, PAGE 36//FIG. 5 DRAWING CALLOUTS, PAGE 42//FIG. 6 COPL FLOW DIAGRAM, PAGE 49//TAB. 1 PROCUREMENT REQUIREMENTS, 327-9020000, PAGE 44//TAB. 2 OPERATIONAL FLUIDS REQUIREMENTS, 327-9020000, PAGE 45//TAB. 3 FINAL SOLVENT RINSE EFFLUENT REQUIREMENTS, 327-9020000, PAGE 46//TAB. 4 VACUUM INSPECTION REQUIREMENTS, 327-9020000, PAGE 47//TAB. 5 TANK FLUSH TEST REQUIREMENTS, 327-9020000, PAGE 48.

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CORPORATE SOURCE -

MARTIN CO., DENVER, COLO.

REPORT NUMBER -

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SYMPOSIUM ON MATERIALS USED IN AEROSPACE VEHICLE DESIGN, MAY 4-6, 1960, DENVER, COLO.

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STUDY OF LIQUID OXYGEN CONTAMINATION, FINAL REPORT.

by

FOSTER, R.H.

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-ABSTRACT-

THIS FINAL REPORT SUMMARIZES THE WORK PERFORMED IN ACCORDANCE WITH CONTRACT AF 33(616)-6730. THE PURPOSE OF THIS STUDY WAS TO DEVELOP A BETTER UNDERSTANDING OF THE PHYSICAL, CHEMICAL AND MECHANICAL RELATIONSHIPS INVOLVED IN DEVELOPING REALISTIC PARAMETERS FOR SPECIFICATION PURPOSES FOR THE APPLICATION OF OXYGEN TO MISSILES. THE SIGNIFICANT SOURCES AND DEGREE OF CONTAMINATION ARE SUPPLIED AS A BACKGROUND SURVEY AND THE CURRENT (1961) SPECIFICATIONS FOR LIQUID OXYGEN AND GROUND SUPPORT EQUIPMENT ARE DISCUSSED. RECOMMENDATIONS FOR LIQUID OXYGEN SPECIFICATIONS AND FOR EQUIPMENT OPERATION ARE PRESENTED. SOURCES AND MECHANISMS FOR IGNITION OF LIQUID OXYGEN SYSTEMS, FACTORS RELATED TO SOLID CONTAMINANTS, CLEANING AND PURIFICATION OF OXYGEN EQUIPMENT AND HANDLING SYSTEMS HAVE BEEN INCLUDED. AS PART OF THIS STUDY, A THREE-MONTH ANALYTICAL SURVEY WAS MADE AT CAPE CANAVERAL AND SUMMARIZED HEREIN.

-PERTINENT FIGURES-

FIG.1 SIMPLIFIED DIAGRAM, LIQUID OXYGEN SUPPLY SYSTEM, PAGE 9//FIG.2 EXAMPLES OF PIPING DETAILS RESULTING IN CONTAMINANT CONCENTRATION BUILD-UP, PAGE 13//FIG.3 FLOW LINES IN LIQUID OXYGEN LAUNCH-SITE STORAGE TANK, PAGE 14//FIG.4 TYPICAL LAUNCH-SITE LIQUID OXYGEN STORAGE AND LOADING SYSTEM, PAGE 15//FIG.5 SOLUBILITY OF CARBON DIOXIDE IN LIQUID OXYGEN, PAGE 23//FIG.6 DIFFERENTIAL VAPORIZATION OF 99.5 PERCENT LIQUID OXYGEN, EFFECT ON CONCENTRATION OF MORE VOLATILE CONTAMINANTS, PAGE 25//FIG.7 SCHEMATIC DRAWING OF APPARATUS USING GASEOUS OXYGEN, PAGE 42//FIG.8 SCHEMATIC DRAWING OF APPARATUS USING LIQUID OXYGEN, PAGE 43//FIG.9 FILM IGNITION EQUIPMENT, PAGE 44//FIG.10 RECOVERY OF HEXADECANE FILMS AFTER SPARK IGNITION IN GASEOUS OXYGEN, PAGE 45//FIG.11 RECOVERY OF HEXADECANE FILMS AFTER IGNITION WITH AN ELECTRIC MATCH IN GASEOUS OXYGEN UNDER 200 PSIG PRESSURE, PAGE 46//FIG.12 RECOVERY OF HEXADECANE FILMS AFTER SPARK IGNITION IN LIQUID OXYGEN, PAGE 47//FIG.13 APPARATUS FOR EXAMINATION OF SOLID CARBON DIOXIDE FILTERING PHENOMENON, PAGE 52//FIG.14 EQUIPMENT FOR EXAMINATION OF THE CC(2) FILTRATION EQUIPMENT, PAGE 53//FIG.15 NEW FILTER ASSEMBLY WITH SIDE TAP, PAGE 54//FIG.16 DISASSEMBLED FILTER, PAGE 55//FIG.17 PLASTIC FILTER ASSEMBLY WITH CYLINDRICAL

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STUDY OF LIQUID OXYGEN CONTAMINATION. PROG. REPT. NO. 3

by

BAILEY, B.M.
VIGNALE, V.J.

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-ABSTRACT-

THE OBJECT OF THIS PROGRAM IS THE RECOMMENDATION OF REALISTIC SPECIFICATIONS FOR PROCUREMENT AND USE OF LIQUID OXYGEN FOR POCKET PROPELLANT SUPPLY SYSTEMS, INCLUDING STANDARDS FOR CLEANLINESS, MONITORING FOR CLEANLINESS AND CONTAMINANTS, AND RECOMMENDATIONS OF DESIGN CRITERIA FOR REDUCTION OF CONTAMINANTS AND INCREASED SAFETY. THIS PROGRESS REPORT RECOMMENDS PROCUREMENT AND USE SPECIFICATIONS FOR TOTAL HYDROCARBONS AND ACETYLENE IN LIQUID OXYGEN. NO SPECIFICATION RECOMMENDATIONS ARE MADE FOR OTHER POSSIBLE CONTAMINANTS FOR LACK OF DEFINITIVE KNOWLEDGE. PROGRAMS FOR OBTAINING THIS INFORMATION HAVE BEEN OUTLINED.

-PERTINENT FIGURES-

FIG.1 DIFFERENTIAL VAPOORIZATION OF 99.5 PERCENT LIQUID OXYGEN - EFFECT ON CONCENTRATION OF LESS VOLATILE CONTAMINANTS, PAGE 15//FIG.2 SOLUBILITY OF CARBON DIOXIDE IN LIQUID OXYGEN, PAGE 19//FIG.3 SOLUBILITY OF CARBON DIOXIDE IN GASEOUS OXYGEN, PAGE 21//FIG.4 DIFFERENTIAL VAPORIZATION OF 99.5 PERCENT LIQUID OXYGEN - EFFECT ON CONCENTRATION OF MORE VOLATILE CONTAMINANTS, PAGE 24//FIG.5 RELATIONSHIP BETWEEN INITIAL CONTAMINANT CONCENTRATION AND LIQUID OXYGEN VAPORIZED, PAGE 26//FIG.6 DIFFERENTIAL VAPORIZATION OF 99.5 PERCENT LIQUID OXYGEN - LIQUID-VAPOR OXYGEN EQUILIBRIUM, PAGE 29//FIG.B-1 CONCENTRATION PROFILES CLOSE TO A SPHERE IMMersed IN AN INFINITE VOLUME OF SOLVENT, PAGE 41//FIG.B-2 FRACTION DISSOLVED IN TERMS OF DIMENSIONLESS TIME AND DRIVING FORCE, PAGE 43// FIG.B-3 REDUCTION IN DIAMETER AS FUNCTION OF CONTACT TIME AND PARTICLE DIAMETER - CARBON DIOXIDE IN LIQUID OXYGEN, PAGE 46//FIG.B-4 TIME REQUIRED TO DISSOLVE CARBON DIOXIDE PARTICLES IN LIQUID OXYGEN, PAGE 50//TAB.1 OXYGEN CONTAMINANTS ANALYSES IN REPRESENTATIVE PLANTS, PAGE 12//TAB.2 CONCENTRATION OF DIFFERENT HYDROCARBONS IN REPRESENTATIVE OXYGEN PLANTS, PAGE 13//TAB.3 PARTICULATE MATTER IN LIQUID OXYGEN, PAGE 17

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CONTAMINATION CONTROL IN LIQUID OXYGEN SYSTEMS.

by

BALL, W.L.

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Summary

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-ABSTRACT-

THIS ARTICLE PROVIDES A CONCISE REVIEW OF CONTAMINATION IN LIQUID OXYGEN. CONTAMINANTS ARE CLASSIFIED IN TERMS OF SOLID OR DISSOLVED, COMBUSTIBLE OR INERT, AND THE SOLUBILITIES OF SELECTED SATURATED AND UNSATURATED HYDROCARBONS IN LIQUID OXYGEN IS GIVEN. DISCUSSED ARE SOURCES OF CONTAMINATION, MEANS OF REMOVAL, AND CONCENTRATION EFFECTS DURING STORAGE AND HANDLING DUE TO POOR EQUIPMENT DESIGN AND VAPOORIZATION.

-PERTINENT FIGURES-

FIG. 1 SOLUBILITY OF SATURATED HYDROCARBONS IN LIQUID OXYGEN PAGE 11//FIG. 2 SOLUBILITY OF UNSATURATED HYDROCARBONS IN LIQUID OXYGEN PAGE 11

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TECHNICAL CHARACTER OF CRYOGENIC HAZARDS (LKS* PART 1 OF
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by

MCKINLEY, C.

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-ABSTRACT-

A GENERAL DISCUSSION OF THE HAZARDS INVOLVED IN HANDLING CRYOGENIC FLUIDS IS GIVEN. THE HAZARDS ARE GROUPED INTO FOUR CATEGORIES, PERSONNEL EXPOSURE, BRITTLENESS OF CONSTRUCTION MATERIALS AT LOW TEMPERATURES, HIGH PRESSURES DUE TO CONFINEMENT OF CRYOGENIC FLUIDS, AND FLUID FLAMMABILITY. BRIEF DISCUSSION AND CONCISE GENERAL DATA ARE GIVEN COVERING THE IMPACT ENERGY OF CARBON STEELS, ADIABATIC COMPRESSION TEMPERATURES, THE FLAMMABILITY AND DETONABILITY LIMITS OF SELECTED HYDROCARBONS IN AIR AND OXYGEN, THE FLAME AND DETONATION VELOCITIES OF METHANE AND HYDROGEN IN AIR AND OXYGEN, THE SOLUBILITY OF UNSATURATED HYDROCARBONS IN LIQUID OXYGEN, THE ADSORPTIVE CAPACITIES OF THE LOWER HYDROCARBONS IN LIQUID OXYGEN, AND EXPERIMENTAL EXPLOSION TEST DATA WITH MIXTURES OF SOLID AND GASEOUS METHANE, NITROUS OXIDE, AND TRICRESYL PHOSPHATE MIXED WITH GASEOUS AND LIQUID OXYGEN. THE ARTICLE BRIEFLY COVERS MANY OF THE HAZARDS INCURRED WITH CRYOGENIC SYSTEMS AND PRESENTS BRIEF DATA TO EXPLAIN WHY THE HAZARDS EXIST.

-PERTINENT FIGURES-

FIG.1 TENSILE AND IMPACT VALUES FOR STEEL AND ALUMINUM, PAGE 24//FIG.2 COEFFICIENTS OF THERMAL EXPANSION, PAGE 24//FIG.3 VAPOR PRESSURES OF HYDROGEN, NITROGEN, ARGON, OXYGEN, CARBON DIOXIDE AND WATER, PAGE 25//FIG.4 DENSITY OF OXYGEN, GASEOUS AND LIQUID, PAGE 25//FIG.5 THRUST FROM ESCAPING GAS, PAGE 26//FIG.6 ADIABATIC COMPRESSION TEMPERATURE, PAGE 26

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by

SMITH, C. P.

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-ABSTRACT-

A GENERAL REVIEW OF CONTAMINATION IN THE PRODUCTION OF VARIOUS CRYOGENS. MOST OF THE DISCUSSION COVERS OXYGEN AND NITROGEN IN AIR SEPARATION PLANTS. SOME INFORMATION IS GIVEN FOR HYDROGEN AND HELIUM. THIS IS A BRIEF ARTICLE AND GIVES ONLY GENERAL INFORMATION.

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GAS-CHROMATOGRAPHIC METHOD FOR THE DETERMINATION OF
POLLUTANTS IN AVIATION LIQUID OXYGEN. (METODO
GASCHROMATOGRAFICO PER LA DETERMINAZIONE DEGLI INQUINANTI
NELL OSSIGENO LIQUIDO AVIO)

by

CIANETTI, E.
PECCI, G.
SCUDERI, G.

00/00/65

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-ABSTRACT-

FOLLOWING AN EXPLANATION OF BASIC PRINCIPLES OF GAS CHROMATOGRAPHY AND SOME TOXICOLOGICAL CONSIDERATIONS OF REASONS FOR REDUCING MAXIMUM ALLOWABLE IMPURITIES IN OXYGEN, THE AUTHORS DESCRIBE A METHOD FOR QUICKLY DETERMINING BOTH ORGANIC AND INORGANIC IMPURITIES. ORGANIC IMPURITIES ARE DETERMINED WITH IONIZING FLAME GAS CHROMATOGRAPHY, INORGANIC ONES WITH A THERMISTOR SENSOR, IN TWO OPERATIONS, AFTER PRECONCENTRATION.

-PERTINENT FIGURES-

FIGS. 1 THRU 4 GAS CHROMATOGRAPHY APPARATUS PAGES 30-1, 34-5//FIGS. 5 THRU 13 CHROMATOGRAMS OF IMPURITIES IN OXYGEN PAGES 37-42//TABLE MAXIMUM ALLOWABLE CONTAMINANTS PAGE 32

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ANALYSIS FOR TRACE HYDROCARBON CONTAMINANTS IN OXYGEN
REBOILERS

by

LINDE, H. W.
SCHMAUCH, G. E.

00/00/66

SECURITY CLASS	ACCESS LEVEL	REPORT CLASS	ENTRY EVAL.
U/Unrestricted	Unlimited	Summary	Acceptable

-ABSTRACT-

IN CONNECTION WITH A PROGRAM TO STUDY THE CONCENTRATIONS OF HYDROCARBON CONTAMINANTS IN OXYGEN REBOILERS, A GAS CHROMATOGRAPHIC TECHNIQUE WAS DEVELOPED TO MEASURE C(3) THROUGH C(6) HYDROCARBON AT THE 1 TO 15 PART-PER-BILLION LEVEL IN VAPORIZED LOX SAMPLES. THE PROCEDURE CONSISTED OF PASSING A LARGE VOLUME OF OXYGEN (3-15 LITERS) THROUGH A SHORT ALUMINA ADSORPTION COLUMN COOLED TO -78 DEGREES C FOLLOWING WHICH THE ADSORPTION COLUMN WAS SWITCHED INTO A GAS CHROMATOGRAPH CARRIER GAS STREAM. THE COOLANT WAS REMOVED AND THE COLUMN IMMersed IN WATER AT 95 DEGREES C. THE HYDROCARBON CONTAMINANTS ELUTED FROM THE ADSORPTION COLUMN WERE CHROMATOGRAPHED ON A 12-FOOT DIBUTYL SEBACATE COLUMN AT 40 DEGREES C. A SINGLE ANALYSIS COULD BE PERFORMED IN 30 MINUTES. THE REBOILERS OF FOUR OXYGEN PLANTS WERE SAMPLED AT WEEKLY INTERVALS OVER A SEVERAL MONTH PERIOD. PROPANE WAS REGULARLY FOUND IN CONCENTRATIONS AS HIGH AS 2300 PPB EACH WHILE THE PENTANES AND HEXANES WERE ORDINARILY BELOW THE DETECTABLE LIMITS BUT OCCASIONALLY ROSE TO THE 20 PPB RANGE.

-PERTINENT FIGURES-

FIG.1 MODIFIED GAS CHROMATOGRAPH, PAGE 368//FIG.2 FLOW DIAGRAM, PAGE 368// FIG.3 CHROMATOGRAM OF STANDARD GAS BLEND, PAGE 370//TAB.1 LIMITS OF HYDROCARBON DETECTION, PAGE 369//TAB.2 HYDROCARBONS IN REBOILER LOX, PAGE 371

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SAFETY OF MATERIALS IN CONTACT WITH LIQUID OXYGEN

by

KELLER, E. E.

02/21/57

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-ABSTRACT-

TEST METHOD AND APPARATUS AND TEST RESULTS OF IMPACT SENSITIVITY OF VARIOUS MATERIALS IN LIQUID OXYGEN ARE PRESENTED. ALSO PRESENTED ARE AN ABSTRACT OF A PAPER ON BEHAVIOR OF LIQUID OXYGEN AND A LITERATURE SURVEY OF REACTIONS OF ORGANIC MATERIALS WITH LIQUID OXYGEN. CONCLUSION IS THAT MOST REDUCING AGENTS AND HYDROCARBONS IN CONTACT WITH LIQUID OXYGEN CONSTITUTE A POTENTIAL EXPLOSIVE HAZARD.

-PERTINENT FIGURES-

DRAWING IMPACT TESTER PAGES 17-26//TABLE 1 IMPACT SENSITIVITY OF MATERIALS IN CONTACT WITH LIQUID OXYGEN PAGES 6-10//TABLE 2 EFFECT OF IMPACT ENERGY ON SENSITIVITY PAGE 11//TABLE 3 EFFECT OF IMPACT ENERGY ON SENSITIVITY PAGE 12 //TABLE 4 IMPACT SENSITIVITY OF MATERIALS IN CONTACT WITH LIQUID OXYGEN PAGE 12(A)

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REVIEW OF NEW SOLUBILITY DATA FOR CERTAIN HYDROCARBONS IN
LIQUID OXYGEN

by

BALL, W.L.

00/00/66

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ACCESS LEVEL
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REPORT CLASS
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ENTRY EVAL.
Acceptable

-ABSTRACT-

THIS IS A SHORT REPORT ON EXPERIMENTAL MEASUREMENT OF THE SOLUBILITY OF CERTAIN HYDROCARBONS DISSOLVED IN LIQUID OXYGEN. THE SOLUBILITY LIMIT DID NOT CHANGE MEASURABLY FOR 30 TO 90 PSI PRESSURE CHANGE. A DESCRIPTION OF THE TEST APPARATUS IS GIVEN AND RESULTS OF TESTS ARE TABULATED.

-PERTINENT FIGURES-

FIG.1 LIQUID PHASE SOLUBILITY APPARATUS, PAGE 12//TAB.1 LIQUID PHASE SOLUBILITIES IN MOLAR PPM, PAGE 13

-SOURCE INFORMATION-

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SAMPLING AND ANALYSIS OF LIQUID OXYGEN, SUPPLEMENT TO
SUMMARY PROGRESS REPORT NO. 4

by

ENT, W.L.

07/00/60

SECURITY CLASS
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Good/Excel.

-ABSTRACT-

THIS SUPPLEMENTAL REPORT TO THE STUDY OF LIQUID OXYGEN CONTAMINATION DISCUSSES THE SAMPLING TECHNIQUES AND ANALYTICAL METHODS WHICH HAVE BEEN USED IN BOTH THE PRODUCTION AND USE OF LIQUID OXYGEN. THE SAMPLING TECHNIQUES AND ANALYTICAL METHODS WHICH ARE NEEDED AND USED HAVE BEEN ESTABLISHED TO MEET THE REQUIREMENTS OF SEVERAL DIFFERENT ASPECTS OF THE PROBLEM, SUCH AS, MONITORING FOR OXYGEN PURITY, MAINTENANCE OF COMBUSTIBLES BELOW DANGEROUS CONCENTRATION LEVELS, CONTROL OF SOLUBLE CONTAMINANTS, AND CONTROL OF SUSPENDED OR CONTAINED SOLID. SAMPLING AND ANALYTICAL TECHNIQUES WHICH ARE THE MOST ACCURATE, SENSITIVE, AND RELIABLE OF THOSE METHODS DISCUSSED, ARE RECOMMENDED. THE RECOMMENDED TECHNIQUES COVER PURITY, TOTAL HYDROCARBON, CARBON DIOXIDE, ACETYLENE, WATER, AND PARTICULATES FOR BOTH PRODUCTION STREAMS, AND LIQUID IN STORAGE.

-PERTINENT FIGURES-

FIG.1 SAMPLING METHODS, PAGES 11, 12, AND 13//FIG.2 ORSAT OXYGEN TEST, PAGE 22//FIG.3 DEW POINT TEMPERATURE OF WATER VAPOR IN AIR, PAGE 29//TAB.1 SELECTED PHYSICAL-CHEMICAL PROPERTIES OF LIQUID OXYGEN CONTAMINANTS, PAGE 3//TAB.2 CO(2) CONTAMINATION STUDY AT MARTIN-DENVER 75 T/D LIQUID OXYGEN FACILITY, PAGE 16//TAB.3 TYPICAL CONTAMINANT CONCENTRATIONS IN HIGH PURITY LOX, PAGE 26

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STUDY OF LIQUID OXYGEN CONTAMINATION. PROG. RPT. NO. 5

by

POSTER, R.H.
VANGELDER, W.
KEHAT, E.

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-ABSTRACT-

THIS PROGRESS REPORT DISCUSSES EXPERIMENTAL WORK DONE ON THE FILTRATION OF SOLID CARBON DIOXIDE (CO₂) FROM LIQUID OXYGEN AND ON HYDROCARBON FILM IGNITION IN GASEOUS OXYGEN. THE EQUIPMENT AND METHODS USED IN THE EXPERIMENTS ARE SHOWN AND DESCRIBED AND THE RESULTS OBTAINED TO DATE ARE DISCUSSED. IT HAS BECOME OBVIOUS THAT COMPLETE FILTRATION OF CO₂ FROM LIQUID OXYGEN IS DIFFICULT AND EXTENSIVE WORK MAY BE REQUIRED TO PROVIDE AN ADEQUATE BASIS FOR THE RECOMMENDATION OF FILTER DESIGN. RESULTS OF THE HYDROCARBON FILM TESTS INDICATE THAT THE LUBRICANT COMPONENT N-HEXADECANE SAFE FILM CONCENTRATION IS PERHAPS 100 MG/SQ.FT. RATHER THAN 4 MG/SQ.FT. AS SPECIFIED AT VARIOUS MISSILE BASES. A FILM THICKNESS OF 250 MG/SQ.FT. CREATES A VISIBLY OILY SURFACE, WHILE 500 MG/SQ.FT. PRODUCES A FILM HAVING DEFINITE FLOW CHARACTERISTICS. THE LATTER SHOULD NEVER BE TOLERATED IN ANY LOX SYSTEM BECAUSE FILMS THICK ENOUGH TO FLOW ARE CAPABLE OF ACCUMULATING IN PUDDLES.

-PERTINENT FIGURES-

FIG.1 APPARATUS FOR EXAMINATION OF SOLID CARBON DIOXIDE FILTERING PHENOMENON, PAGE 9//FIG.7 PLASTIC FILTER ASSEMBLY WITH CYLINDRICAL FILTER ELEMENT (FULL SIZE), PAGE 15//FIG.8 FILTER ASSEMBLY AS MODIFIED WITH SIDE TAKE-OFF FOR HIGH REYNOLDS NUMBER (FULL SIZE), PAGE 15//FIG.9 REYNOLDS NUMBER BEFORE FILTER (10 MICRON PORE SIZE) QUIESCENT STATE, PAGE 22//FIG.10 REYNOLDS NUMBER BEFORE FILTER (10 MICRON PORE SIZE) VIBRATED FILTER, PAGE 23 //FIG.11 REYNOLDS NUMBER BEFORE FILTER, PAGE 24//FIG.13 PERCENT RECOVERY OF HEXADECANE AFTER SPARK IGNITION, PAGE 28//TAB.I RESULTS OF CO₂ FILTRATION RUNS, PAGE 17//TAB.II RECOVERY OF N-HEXADECANE FROM HYDROCARBON IGNITION TESTS, PAGE 29

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-ABSTRACT-

NUMEROUS ASPECTS OF CRYOGENIC PLANT SAFETY ARE REVIEWED. THE IMPORTANCE OF PLANT STARTUP HAZARDS ARE DISCUSSED, WITH SPECIAL EMPHASIS BEING GIVEN TO USING AN EXPERIENCED OPERATING CREW, CHECKING EMERGENCY EQUIPMENT, CLEANING OUT INITIAL PIPING CONTAMINATION, AND THE INITIAL OPERATING EQUIPMENT CHECKOUT. SPECIFIC TOPICS OF PLANT SAFETY DISCUSSED ARE TOTAL HYDROCARBON AND ACETYLENE CONTAMINATION, ACETYLENE SOLUBILITY, AND CONTAMINATION LIMITS, CONTAMINATION MONITORING, LOX STORAGE TANK CLEANING METHODS AND CRITERIA, AND THE USE OF NON-SPARKING TOOLS IN OXYGEN ENRICHED AND HYDROGEN ENVIRONMENTS. THE HAZARDS ENUMERATED ARE BRIEFLY DISCUSSED AND THE EXISTING OPERATING POLICY OF THE AIR PRODUCTS COMPANY TOWARD MINIMIZING THESE HAZARDS IS GIVEN.

-PERTINENT FIGURES-

TAB. 1 MONITORING FOR CONTAMINANTS PAGE 43

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SOURCES OF CONTAMINATION, TOLERABLE LIMITS, AND REMEDIAL
PROCEDURES

by

BALL, W.L.

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-ABSTRACT-

MANY OF THE PROBLEMS ASSOCIATED WITH CONTAMINANTS IN AIR SEPARATION PLANTS ARE DISCUSSED, THE SOURCES OF CONTAMINATION, THE TOLERABLE NORMAL OPERATING LIMITS, THE MAXIMUM SAFE OPERATING LIMITS, AND REMEDIAL PROCEDURES TO BE TAKEN WHEN THE MAXIMUM LIMIT IS EXCEEDED. THE RELATIONSHIP BETWEEN THE GAS PHASE FLAMMABILITY LIMITS OF FUEL-OXYGEN MIXTURES SOLUBLE OR SOLID FUEL CONTAMINANTS IN LIQUID OXYGEN ARE BRIEFLY DISCUSSED. THE EQUILIBRIUM SOLUBILITIES OF NITRIC OXIDE, NITROGEN DIOXIDE, THE LIGHTER SATURATED AND UNSATURATED HYDROCARBONS, AND ACETYLENE IN LIQUID OXYGEN ARE GIVEN. THE LOWER FLAMMABILITY LIMITS OF THE LIGHTER HYDROCARBONS IN GASEOUS OXYGEN ARE GIVEN. DESIRABLE LOCATIONS FOR CONTAMINATION SAMPLING POINTS, AND PLACES WHERE CONTAMINANTS WOULD BE MOST LIKELY TO CONCENTRATE IN AN AIR SEPARATION PLANT ARE GIVEN. THE PURIFICATION ROLES OF ADSORBERS, DRYERS, PURIFIERS, SCRUBBERS, FILTERS, HEAT EXCHANGERS, INTERCOOLERS, AFTERCOOLERS, AND REGENERATORS FOR REMOVING CONTAMINANTS IN A TYPICAL AIR SEPARATION PLANT PROCESS ARE DISCUSSED. SPECIAL PROBLEMS ASSOCIATED WITH OZONE, NITRIC OXIDES, AND ACETYLENE ARE REVIEWED. PRECAUTIONS TO BE TAKEN WHEN SHUTTING DOWN A PLANT BECAUSE OF EXCESSIVE CONTAMINATION AND ASSOCIATED CONTAMINATED FLUID DISPOSAL ARE DISCUSSED. THE ARTICLE PRESENTS A CONCISE, GENERAL PICTURE OF THE CONTAMINATION PROBLEMS ASSOCIATED WITH AIR SEPARATION PLANTS.

-PERTINENT FIGURES-

FIG.1 SOLUBILITY OF SATURATED HYDROCARBONS IN LIQUID OXYGEN, PAGE 71//FIG.2 SOLUBILITY OF UNSATURATED HYDROCARBONS IN LIQUID OXYGEN, PAGE 72//FIG.3 NONCIRCULATING OXYGEN SYSTEM, PAGE 73//FIG.4 CIRCULATING OXYGEN SYSTEM, PAGE 74//FIG.5 SIMPLIFIED FLOW DIAGRAM, TYPICAL HIGH PRESSURE AIR SEPARATION PLANT, PAGE 76//TAB.1 GAS PHASE FLAMMABLE LIMIT-CARBON ATOM APPROXIMATION, PAGE 70

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SAFETY ASPECTS OF RECONSTRUCTED ICI TONNAGE OXYGEN PLANT

by

MATTHEWS, W.D.
OWEN, G.G.

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-ABSTRACT-

ON 21ST APRIL, 1959, A SERIOUS EXPLOSION OCCURRED IN THE TONNAGE OXYGEN PLANT AT THE WORKS OF IMPERIAL CHEMICAL INDUSTRIES LIMITED AT BILLINGHAM-ON-TEES, ENGLAND, DURING THE COMMISSIONING PROCEDURES. THE EXPLOSION CAUSED THREE DEATHS, AND EXTENSIVE DAMAGE BOTH TO THE PLANT AND TO NEARBY FACILITIES. A COMPREHENSIVE AND DETAILED INVESTIGATION WAS UNDERTAKEN JOINTLY BY AIR PRODUCTS LTD. AND ICI, AND EXPERT ASSISTANCE WAS ALSO PROVIDED FROM INDEPENDENT SOURCES. WHILE THE INVESTIGATION CONCLUDED THAT THE CONSTITUENTS OF THE EXPLOSIVE MATERIAL WERE HYDROCARBON OIL FROM THE LUBRICATING SYSTEM OF THE TURBO EXPANDERS AND LIQUID OXYGEN FROM LEAKING PIPE JOINTS IN THE COLD BOX, A CRITICAL REAPPRAISAL (IN THE LIGHT OF THE GROWING KNOWLEDGE OF THE HAZARDS ASSOCIATED WITH AIR SEPARATION PLANTS) OF ALL ASPECTS OF PROCESS AND ENGINEERING DESIGN, FABRICATION AND ERECTION, WHICH COULD BE REGARDED IN ANY WAY AS BEING POTENTIALLY HAZARDOUS, WAS UNDERTAKEN BY ICI AND A.P. PRIOR TO AND DURING THE RECONSTRUCTION OF THE PLANT. AT THE SAME TIME, AIR PRODUCTS LTD. INTRODUCED CERTAIN IMPROVEMENTS RELATING TO THE CYCLE, THIS PAPER, HOWEVER, IS CONFINED TO CONSIDERATION ONLY OF THOSE CHANGES WHICH WERE RELEVANT TO SAFETY.

-PERTINENT FIGURES-

FIG.9 FINAL DESIGN OF LOX JOINT, PAGE 9//FIG.10 STRESS VARIATION IN LOX FLANGE BOLTS DURING COOLING CYCLES, PAGE 9

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CORPORATE SOURCE -

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SAFETY IN DISPOSAL OF LARGE QUANTITIES OF LIQUID OXYGEN

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-ABSTRACT-

THE MAJOR HAZARD COVERED IN THIS ARTICLE IS ENCOUNTERED BECAUSE OF OXYGEN'S AFFINITY FOR HYDROCARBONS. THE HYDROCARBON HAZARD IS NOT CONFINED TO EXTERNAL SOURCES OF CONTAMINANTS ALONE. THE REASON FOR DISPOSING OF THE LIQUID MAY BE A HIGH HYDROCARBON CONCENTRATION WITHIN THE OXYGEN OF THE MAIN REBOILER ITSELF. THIS PROBLEM IS NOT LIMITED TO THE DISPOSAL OF LIQUID OXYGEN ALONE. IN THE DRAINING OF OXYGEN-RICH LIQUIDS, OR EVEN AIR, SLOW EVAPORATION IN A POT WILL GRADUALLY ENRICH THE OXYGEN CONTENT. OXYGEN PURITIES ABOVE 98 PERCENT ARE READILY ATTAINABLE, AS THE LAST LIQUID VAPORIZES, IF THE BOILING IS SLOW ENOUGH FOR EQUILIBRIUM CONDITIONS TO EXIST. THUS, THE MERE PRESENCE OF NITROGEN IN THE LIQUID DOES NOT ELIMINATE THE HAZARD OR PERMIT CARELESS DISPOSAL TECHNIQUES. ON THE CONTRARY, WHERE TRANSFER LINE GEL TRAPS OR THEIR EQUIVALENT ARE USED, THE OXYGEN-RICH LIQUID TAKEN BEFORE THE TRAPS MAY PRESENT A FAR GREATER DISPOSAL HAZARD THAN THE CLEAN LIQUID OXYGEN FROM THE REBOILER. THIS GREATER HAZARD BEING CREATED BY CONCENTRATING BOTH THE HYDROCARBONS AND THE OXYGEN AS THE LIQUID EVAPORATES. THE FIRST ITEM IN ANY LIQUID DISPOSAL SYSTEM THAT MUST BE CONSIDERED IS THE DESIGN OF THE LIQUID DRAIN PIPING FROM THE MAIN OXYGEN REBOILER OR OTHER VESSEL TO THE POINT OF LIQUID DISPOSAL. THERE ARE A FEW GENERAL CONSIDERATIONS TO BE KEPT IN MIND DURING THE DESIGN OF THIS PIPING, AND THESE ARE DISCUSSED. SEVERAL METHODS OF DISPOSING OF THE LIQUID OXYGEN HAVE BEEN TRIED IN THE PAST YEARS INCLUDING THE USE OF LARGE TANKS, GRAVEL-FILLED DRAIN PITS, AND VARIOUS STYLES OF HEAT EXCHANGERS. WHILE CLEAN TANKS MAY BE CONSIDERED A SAFE MEANS OF HOLDING THE LIQUID UNTIL IT VAPORIZES FROM NATURAL OR SUPPLIED HEAT LEAK, UNDER SOME CONDITIONS THE GRADUAL CONCENTRATION OF HYDROCARBONS, PARTICULARLY ACETYLENE, CAN MAKE THIS METHOD POTENTIALLY DANGEROUS. THIS HAZARD IS MORE SERIOUS WITH CONTAMINATED OXYGEN-RICH LIQUIDS SINCE THE SLOW BOILING INCREASES BOTH THE OXYGEN AND HYDROCARBON CONCENTRATIONS. THIS METHOD HAS HAD A FAIRLY GOOD SERVICE RECORD, BUT IT SHOULD BE AVOIDED WHERE POSSIBLE. THE BEST METHOD OF VAPORIZING LIQUID OXYGEN IS IN A VAPORIZER IN WHICH THE OXYGEN IS FLASHED TO GAS AT AMBIENT OR HIGHER TEMPERATURE. THIS ENSURES THAT THE HYDROCARBONS, AND ESPECIALLY ACETYLENE, ARE ALSO VAPORIZED INSTANTANEOUSLY AND CANNOT ACCUMULATE TO HAZARDOUS PROPORTIONS. THE METHOD IS DETAILED IN THIS ARTICLE.

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-ABSTRACT-

THIS IS A TRANSCRIPT OF AN AIR SEPARATION PLANT SAFETY SYMPOSIUM CONVENED AT THE A.I.C.H.E. NATIONAL MEETING IN ST. PAUL, MINNESOTA. TOUCHED ON IN THIS SHORT ARTICLE ARE CONTAMINATION LIMITS AND ANALYSIS, THE NAVY CRYOGENIC SAMPLER, AND SOME TRIVIAL COMMENTS ON NITROGEN OXIDES IN LIQUID OXYGEN.

-PERTINENT FIGURES-

FIG. DETAILS ON SAMPLER PREPARATION, PAGE 7

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L AIR LIQUIDE, MONTREAL//NAVAL AIR STATION, ALAMEDA,
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SAFE DESIGN AND OPERATION OF LOW TEMPERATURE AIR SEPARATION
PLANTS

by

KERRY, F.G.

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-ABSTRACT-

THE HISTORY OF OPERATION OF AIR SEPARATION PLANTS FOR THE PRODUCTION OF OXYGEN HAS BEEN RELATIVELY FREE OF EXPLOSIONS AND SIMILAR SUCH ACCIDENTS PRIMARILY DUE TO CAREFUL ATTENTION TO SAFE OPERATING PRACTICES AND SAFE DESIGN OF PLANTS. THERE HAVE BEEN A NUMBER OF SERIOUS ACCIDENTS AND EXPLOSIONS HOWEVER, PARTICULARLY IN RECENT YEARS IN SOME OF THE LARGER PLANTS THAT OPERATE CONTINUOUSLY. THESE HAVE BEEN DUE MOSTLY TO EXCESSIVE LEVELS OF ACETYLENE OR OTHER HYDROCARBON CONTAMINANTS. STUDIES HAVE REVEALED THAT BREAKDOWN OF LUBRICATING OILS IN THE COMPRESSOR OR EXPANDER AND RELATED CONTAMINATION OF THE AIR STREAM HAS LEAD TO EXCESSIVE HYDROCARBON LEVELS IN THE LIQUID OXYGEN. PROPER PLANT DESIGN AND OPERATING PROCEDURES CAN ESSENTIALLY ELIMINATE EXPLOSIONS AND ACCIDENTS IN LIQUID AIR PLANTS. INCLUDED IN THE PAPER ARE SAFETY PLANT DESIGN FEATURES, SAFE OPERATING PRACTICES AND EXAMPLES OF CONTAMINATION LEVELS AND THEIR CONTROL.

-PERTINENT FIGURES-

FIG.2 ACETYLENE AND HYDROCARBON CONTENT VS WIND DIRECTION, PAGE 5//FIG.3 STANDARD PLANT - NO AUXILIARY VAPORIZER, PAGE 7//FIG.4 STANDARD PLANT WITH AUXILIARY VAPORIZER, PAGE 8//FIG.5 FORCED-FEED, FILM TYPE VAPORIZER, PAGE 6

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THE ROLE OF AIR CONTAMINANTS IN FORMULATING OXYGEN PLANT
SAFETY PRINCIPLES

by

MCKINLEY, C.
HIMMELBERGER, P.

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-ABSTRACT-

THIS ARTICLE TRACES THE HISTORY OF THE DEVELOPMENT OF AIR SEPARATION PLANTS RELATIVE TO SAFETY FROM EXPLOSIONS DUE TO CONTAMINANTS THAT REACT WITH OXYGEN. A TABLE OF ABOUT 25 COMMON CONTAMINANTS IN AN AIR PLANT SHOWS THE NORMAL BOILING AND FREEZING POINTS. ANOTHER TABLE SHOWING THE SOLUBILITY LIMITS OF MOST OF THESE CONTAMINANTS IS ALSO GIVEN. THE EXPLOSION CHARACTERISTICS AND FLAMMABILITY LIMITS OF SEVERAL OF THE CONTAMINANTS IN LIQUID OXYGEN ARE DISCUSSED. METHODS OF CONTAMINATION LEVEL CONTROL OR REMOVAL ARE MENTIONED. ALSO DISCUSSED ARE METHODS OF PREVENTING EXPLOSIONS. EXPERIMENTAL EXPLOSION TEST DATA IS GIVEN. CONTINUOUS HYDROCARBON ANALYSIS IS RECOMMENDED.

-PERTINENT FIGURES-

FIG. 1 METHANE-LIQUID OXYGEN PHASE SYSTEM, PAGE 11//FIG. 2 ETHANE-LIQUID OXYGEN PHASE SYSTEM, PAGE 11//FIG. 3 EXPLOSION TESTING APPARATUS, PAGE 17//FIG. 4 SCHEMATIC DIAGRAM OF CONTINUOUS TOTAL HYDROCARBON ANALYZER, PAGE 15//FIG. 6 SAMPLE STRIP CHART FROM ANALYZER SHOWING OPERATING CYCLE, PAGE 17//TAB. 1 PROPERTIES OF SOME AIR CONTAMINANTS, PAGE 11//TAB. 2 SOLUBILITY OF VARIOUS MATERIALS IN LIQUID OXYGEN, PAGE 11//TAB. 3 GAS PHASE FLAMMABLE LIMIT - CARBON ATOM APPROXIMATION, PAGE 15//TAB. 4 FLAMMABILITY AND DETONABILITY LIMITS - GASES, PAGE 15//TAB. 5 EXPERIMENTAL EXPLOSION TEST DATA, PAGE 14//TAB. 6 TYPE OF CONTAMINANT ANALYSES, PAGE 17

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LONG-TERM STORAGE OF LIQUID OXYGEN

-ABSTRACT-

WHEN LIQUID OXYGEN IS STORED, THE ONLY REAL HAZARD IS PRESENTED BY THE GRADUAL ACCUMULATION OF ACETYLENE OVER A LONG PERIOD OF TIME. IF ON-SITE STORAGE TANKS WERE FILLED AND TOPPED OFF WITH LIQUID OXYGEN THAT HAD 0.5 PARTS PER MILLION (PPM) OR LESS ACETYLENE, THE CONTINUOUS INCREASE IN ACETYLENE CONCENTRATION WOULD NOT BECOME HAZARDOUS FOR THREE YEARS. THE EFFECT DEPENDS NOT ON THE SIZE OF THE STORAGE FACILITY, BUT RATHER ON THE HEAT-LEAK LOSSES. THE THREE-YEAR SAFETY PERIOD ASSUMES A HEAT-LEAK LOSS OF 0.4 PERCENT PER DAY. THERE ARE TWO EXCELLENT WAYS TO EXTEND THE PERIOD OF SAFE OPERATION. THE FIRST METHOD PREVENTS ACETYLENE BUILD-UP BY PURIFYING THE LIQUID OXYGEN INTRODUCED INTO THE STORAGE TANK DURING THE TOPPING OPERATION. THE STORAGE TANK SHOULD BE FILLED INITIALLY WITH LIQUID OXYGEN CONTAINING 0.5 PPM OF ACETYLENE. THEREAFTER, EACH MONTHLY ADDITION SHOULD BE PASSED THROUGH A 14-POUND SILICA-GEL BED AT A FLOW RATE OF 700 GPH, THEREBY ELIMINATING ACETYLENE AND ETHYLENE FROM THE ADDED LIQUID OXYGEN. LARGER SILICA-GEL BEDS WOULD OBVIOUSLY PROVIDE HIGHER FLOW RATES. THE SILICA-GEL BED CAN GENERALLY BE ADDED AS AN APPENDAGE TO THE CURRENT LIQUID-OXYGEN LOADING CONNECTIONS. SHOULD THIS PROCEDURE BE USED, THE INITIAL CONCENTRATION OF ACETYLENE WILL NEVER BE INCREASED OR DECREASED. MOREOVER, ONE NEED NOT BE CONCERNED ABOUT EXCESSIVE LOSSES DUE TO BOIL-OFF DURING PURIFICATION, SINCE MOST OF THE LIQUID OXYGEN WOULD BE EITHER IN THE TRAILER OR IN THE STORAGE FACILITY. THE SECOND METHOD USES SMALL QUANTITIES OF FLUORINE. IT IS BELIEVED THAT LESS THAN 0.5 PERCENT OF FLUORINE ADDED TO THE LIQUID OXYGEN ENTERING THE TANK WOULD REACT PREFERENTIALLY WITH ACETYLENE, AND FORM INERT, SOLUBLE PREONS. THE SPECIFIC IMPULSE OF THE FUEL WOULD NOT BE AFFECTED BECAUSE THE FLUORINE WOULD BE USED UP BY CHEMICAL REACTION WITH THE ACETYLENE, AND BY VERY SLOW EVAPORATION WITH THE GASEOUS OXYGEN LOST FROM THE TANK. EXPERIMENTS SHOULD BE CARRIED OUT IN THE LABORATORY TO DECIDE WHETHER THE ADVANTAGES OF TOTAL ELIMINATION OF THE ACETYLENE WOULD OFFSET THE DISADVANTAGES OF HANDLING FLUORINE.

-PERTINENT FIGURES-

FIG.1 ACCUMULATION OF ACETYLENE IN LOX STORAGE TANKS, PAGE 9//FIG.2 ACCUMULATION OF ETHYLENE IN LOX STORAGE TANKS, PAGE 10//FIG.3 POSSIBLE CHROMATOGRAPHIC DETECTION OF CONTAMINANT CONCENTRATION IN STORED LOX, PAGE 14//FIG.4 DECONTAMINATION OF LOX ON SITE, PAGE 20//TAB.1 CONTAMINANTS OF INTEREST IN LIQUID OXYGEN, PAGE 5//TAB.2 POSSIBLE CONCENTRATION OF ACETYLENE, ETHYLENE AND METHANE IN LOX, PAGE 6

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PRESENT STATUS OF THE HYDROCARBON SITUATION IN AIR
SEPARATORS

by

KARWAT, I.E.

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-ABSTRACT-

THE TITLE OF THIS PAPER PRESENT STATUS OF THE HYDROCARBON SITUATION IN AIR SEPARATORS APTLY DESCRIBES ITS CONTENT. AVERAGE AND MAXIMUM VALUES FOUND IN 85 SAMPLES DRAWN FROM THE AIR IN 16 INDUSTRIAL PLANTS ARE GIVEN. IN THE LIGHT OF THESE FIGURES AND RECENT EXPERIENCE IN THE FIELD, THE OPERATION OF AIR SEPARATION PLANTS IN GENERAL IS CONSIDERED TO BE OF HIGHER INHERENT SAFETY THAN PREVIOUSLY THOUGHT. HYDROCARBON CONCENTRATIONS FOR CRITICAL COMPONENTS IN SEVERAL DIFFERENT PLANTS ARE PRESENTED, VAPORIZER AND ADSORBER OPERATIONS AND CHARACTERISTICS ARE DISCUSSED, AND A GOOD REPRESENTATIVE SAMPLING METHOD IS OUTLINED IN THE PAPER.

-PERTINENT FIGURES-

FIG.1 AIR SAMPLE TAKING IN THE PLANT AREA, PAGE 43//FIG.2 RECYCLING OF SURPLUS LIQUID FROM AN ADDITIONAL VAPORIZER, PAGE 45//FIG.3 FILTER AND ADSORBER IN A VAPORIZER CIRCUIT, PAGE 46//FIG.4 CONCENTRATION DROP OF VARIOUS HYDROCARBONS IN GAS PHASE ADSORPTION. 13 DAYS AFTER START, PAGE 46// FIG.5. SAMPLING ARRANGEMENT FOR LIQUID GASES, PAGE 47//TAB.1 HYDROCARBON CONCENTRATION IN AIR SAMPLES FROM VARIOUS PLANTS, PAGE 44//TAB.2 HYDROCARBON CONCENTRATION IN LIQUID AND GASEOUS OXYGEN, PAGE 45

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THE BEHAVIOUR OF CONTAMINANTS IN AN AIR SEPARATION PLANT

by

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-ABSTRACT-

IN CONSIDERING THE RESULTS OF THE ANALYTICAL PROGRAM, IT IS APPARENT THAT THERE IS MUCH TO BE LEARNED CONCERNING THE CONTAMINANT PROBLEM IN AIR SEPARATION PLANTS. IN PARTICULAR, THERE IS A NEED FOR GREATER KNOWLEDGE OF THE PHYSICAL AND CHEMICAL PROPERTIES OF CONTAMINANTS AT LOW TEMPERATURES, THE EFFECT OF IRREGULAR VARIATION IN PROCESS OPERATION AND THE ABILITY OF PROCESS EQUIPMENT TO MINIMIZE THE EFFECT OF WIDE VARIATIONS IN AIR POLLUTION CONDITIONS. WITH THE CONTINUED IMPROVEMENT OF ANALYTICAL PROCEDURES AND INSTRUMENTATION, A MORE DETAILED APPRAISAL OF THESE PROBLEMS SHOULD BE OBTAINED. FROM THE PRESENT ANALYTICAL STUDY A NUMBER OF GENERAL CONCLUSIONS MAY BE DRAWN. IN PART, THERE IS ALREADY AN APPRECIATION IN THE INDUSTRY OF SOME OF THESE FACTORS.

1. THE EFFICIENCY OF CONTAMINANT REMOVAL BY AIR HEAT EXCHANGERS CANNOT BE PREDICTED SOLELY ON THE BASIS OF CONTAMINANT VAPOUR PRESSURE DATA.
2. THE EFFICIENCY OF CATALYTIC FILTERS IS REDUCED AT LOW CONCENTRATIONS.
3. RICH LIQUID SILICA GEL FILTERS ARE VERY EFFECTIVE IN REMOVING SMALL QUANTITIES OF ACETYLENE BUT ARE ONLY PARTIALLY EFFECTIVE IN REMOVING C(3)-C(5) PARAFFINS. THEIR EFFECTIVENESS FOR THE LATTER IS FURTHER REDUCED BY THE PRESENCE OF LARGE AMOUNTS OF CARBON DIOXIDE AND NITROUS OXIDE ON THE FILTER.
4. THERE IS CONSIDERABLE PROBABILITY THAT SOLID ACCUMULATIONS OF CONTAMINANTS WILL OCCUR ON THE WALLS OF VAPOURIZERS EVEN THOUGH THE AVERAGE CONCENTRATION IN THE BULK LIQUID PHASE IS WELL BELOW THE SOLUBILITY LIMIT. IN THE CASE OF AUXILIARY VAPOURIZERS, SIGNIFICANT QUANTITIES MAY BE DEPOSITED AT QUITE LOW INTAKE CONCENTRATIONS OVER A ONE-MONTH PERIOD. THIS EMPHASIZES THE NEED FOR REGULAR DERIVING OF THESE UNITS.

-PERTINENT FIGURES-

FIG. 1 WEEKLY VARIATION OF CONTAMINANTS ON RICH LIQUID FILTER, PAGE 39// TAB. 1 CONCENTRATION OF CONTAMINANTS IN PROCESS STREAMS, PAGE 40// TAB. 2 CONTAMINANTS HELD ON WALLS OR REGENERATORS (EXCLUDING H(2)O AND CO(2)), PAGE 40// TAB. 3 CONTAMINANTS HELD ON WALLS OF MAIN VAPOURIZER, PAGE 41// TAB. 4 CARBON DIOXIDE AND NITROUS OXIDE DERIVED, PAGE 41// TAB. 5 ACETYLENE AND OXIDES OF NITROGEN DERIVED, PAGE 42// TAB. 6 C(3)-C(5) HYDROCARBONS DERIVED, PAGE 42// TAB. 7

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OXYGEN PLANT VAPORIZER EXPLOSION

by

WRIGHT, G.T.

04/00/61

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-ABSTRACT-

AN EXPLOSION OCCURRED IN THE VAPORIZER OF A LIQUID AIR SEPARATION PLANT AT THE DOMINION FOUNDRIES AND STEEL, LTD, HAMILTON, ONTARIO, SEPT. 30, 1959. THE AUTHOR DESCRIBES THE AIR LIQUEFICATION, PURIFICATION AND SEPARATION CYCLE BRIEFLY AND THEN SPECULATES ON THE CAUSE OF THE EXPLOSION. AN EXCESSIVE ACCUMULATION OF ACETYLENE IN THE VAPORIZER DUE TO EXCESSIVE WARMING OF THE REGENERATOR IS BELIEVED TO HAVE CAUSED THE EXPLOSION. THE SOURCE OF THE CONTAMINANT MOST LIKELY CAME FROM NEARBY CORE OVENS. LARGE VOLUMES OF CO(2) WERE ALSO PRESENT. THE DAMAGE TO THE PLANT IS ILLUSTRATED AND DESCRIBED BRIEFLY. MANY CORRECTIVE MEASURES WERE MADE TO THE PLANTS AND IN THE OPERATING PROCEDURES. SAFETY ALARMS AND PURIFICATION TESTS WERE ADDED. THE PAPER IS PRIMARILY CONCERNED WITH SAFETY.

-PERTINENT FIGURES-

TAB.1 ACETYLENE CONTAMINANT LEVELS IN PLANT OPERATION, PAGE 11//TAB.2 CONTAMINANTS ON THE RICH-LIQUID AND LIQUID OXYGEN FILTERS IN NO. 2 AND NO. 3 PLANTS, PAGE 11

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SAFETY ASPECTS OF MODERN AIR SEPARATION PLANT CYCLES

by

KERRY, F.G.

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-ABSTRACT-

THIS PAPER BRIEFLY DESCRIBES SOME OF THE MODERN AIR SEPARATION PLANT CYCLES SUCH AS THE MEDIUM PRESSURE, LOW PRESSURE AND HIGH PRESSURE CYCLES RELATIVE TO SAFETY IN DESIGN AND OPERATION. PARTICULAR EMPHASIS IS PLACED ON THE CONTROL AND REMOVAL OF CONTAMINANTS THAT COULD REACT WITH OXYGEN IF THE CONCENTRATION LEVELS BECOME EXCESSIVE. THE SOLUBILITY OF HYDROCARBONS AND ACETYLENE ARE ILLUSTRATED. THE USE OF SILICA GEL FILTERS FOR CONTAMINANT REMOVAL IS DESCRIBED.

-PERTINENT FIGURES-

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RESEARCH STUDY OF LIQUID OXYGEN CONTAMINATION, PROG. REPT.

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BAILEY, B.M.
VIGNALE, V.J.

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-ABSTRACT-

(UNCLASSIFIED) THE OBJECT OF THIS PROGRAM IS THE RECOMMENDATION OF REALISTIC SPECIFICATIONS FOR PROCUREMENT AND USE OF LIQUID OXYGEN IN MISSILE OXYGEN-SUPPLY-SYSTEMS. THESE SPECIFICATIONS WILL BE BASED ON THE ANALYSIS OF EXISTING KNOWLEDGE AND THE DEVELOPMENT OF FURTHER INFORMATION CONCERNING THE RELATIONSHIPS BETWEEN THE MISSILE OXYGEN-SUPPLY-SYSTEM FUNCTIONS AND THE LIQUID OXYGEN PURITY. EACH STEP IN THE MISSILE OXYGEN-SUPPLY-SYSTEM FROM THE GENERATION OF THE LIQUID OXYGEN TO ITS FINAL USE IN THE MISSILE IS BEING STUDIED TO DETERMINE THE CONTROLLING FACTORS. THIS PROGRESS REPORT DISCUSSES THE COMBUSTIBLE CONTAMINANTS INTRODUCED DURING THE GENERATION OF LIQUID OXYGEN AND ANALYZES THE PROBLEMS ASSOCIATED WITH THE FLAMMABLE NATURE OF THESE CONTAMINANTS.

-PERTINENT FIGURES-

FIG.1 BASIC FUNCTIONS IN LOX SUPPLY OPERATIONS, PAGE 11//FIG.2 FLOW DIAGRAM OF A LIQUID OXYGEN GENERATOR, PAGE 17//FIG.3 SOLUBILITY OF SATURATED HYDROCARBONS IN LIQUID OXYGEN, PAGE 28//FIG.4 SOLUBILITY OF UNSATURATED HYDROCARBONS IN LIQUID OXYGEN, PAGE 29//TAB.1 SOME GASES AND VAPORS WHICH MAY BE PRESENT IN THE AIR FEED OF LIQUID OXYGEN GENERATORS, PAGE 14//TAB.2 PROPERTIES OF POSSIBLE INGREDIENTS OF AIR, PAGE 15

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AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, SALT LAKE CITY, UTAH,
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COMPOSITION AND ANALYSIS OF COMMERCIAL LIQUID OXYGEN

by

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-ABSTRACT-

FOREIGN MATERIALS IN LIQUID OXYGEN NORMALLY COME FROM THE ATMOSPHERE AND FROM THE PRODUCTION PROCESS WHERE IT IS NOT ECONOMICALLY FEASIBLE TO COMPLETELY REMOVE THEM. THIS ARTICLE SETS FORTH THE COMPOSITION OF COMMERCIAL LIQUID OXYGEN. AND DESCRIBES METHODS OF PURIFICATION AND ANALYSIS.

-PERTINENT FIGURES-

TAB. 2 MAXIMUM LIMITS OF CONTAMINANTS FOR BREATHING OXYGEN LIQUID AND MISSILE PROPELLANT OXYGEN, PAGE 546

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CORPORATE SOURCE -

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-ABSTRACT-

THIS SPECIFICATION COVERS LIQUID AND GASEOUS AVIATORS BREATHING OXYGEN. INCLUDED ARE A LISTING OF OTHER APPLICABLE DOCUMENTS (SPECIFICATIONS AND STANDARDS), A TABLE OF MAXIMUM PERMISSIBLE CONTAMINANT CONCENTRATIONS, A TABLE LISTING OXYGEN CYLINDER FILL PRESSURES FOR VARIOUS TEMPERATURES, AND INSPECTION, SAMPLING AND TESTING REQUIREMENTS AND PROCEDURES.

-PERTINENT FIGURES-

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MILITARY SPECIFICATION MIL-V-2, VALVE CYLINDER, GAS (FOR COMPRESSED OR LIQUEFIED GASES) GENERAL SPECIFICATION FOR//MILITARY SPECIFICATION MIL-D-3716, DESICCANTS, ACTIVATED FOR DYNAMIC DEHUMIDIFICATION//MILITARY SPECIFICATION MIL-L-25567, LEAK TEST COMPOUND, OXYGEN SYSTEMS//MILITARY SPECIFICATION MIL-T-27730, TAPE, ANTISEIZE, TETRAFLUOROETHYLENE, WITH DISPENSER//MILITARY STANDARD MIL-STD-101, COLOR CODE FOR PIPELINES AND FOR COMPRESSED GAS CYLINDERS//MILITARY STANDARD MIL-STD-129, MARKING FOR SHIPMENT AND STORAGE

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OXYGEN SPECIFICATION

-ABSTRACT-

THIS STANDARD IS FOR PROCUREMENT OF LIQUID AND GASEOUS OXYGEN AND IS APPLICABLE TO MSPC AND ITS CONTRACTORS. THREE GRADES ARE SPECIFIED, A-FOR FUEL CELLS, B-FOR BREATHING AND C-FOR PROPELLANTS. ALLOWED CONTAMINANT LEVELS ARE SPECIFIED FOR EACH GRADE FOR SEVERAL SPECIFIC DISSOLVED AND SOLID CONTAMINANTS.

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STUDY OF LIQUID OXYGEN CONTAMINATION, SUMMARY PROGRESS
REPORT NO. 4

by

BAILY, B.M.
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VIGNALE, V.J.

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-ABSTRACT-

THIS SUMMARY PROGRESS REPORT NO. 4 PRESENTS A REVIEW OF THE WORK PERFORMED IN ACCORDANCE WITH CONTRACT AF 33(616)-6730. THE PURPOSE OF THIS STUDY IS TO DEVELOP A BETTER UNDERSTANDING OF THE PHYSICAL-CHEMICAL AND MECHANICAL RELATIONSHIPS INVOLVED AND TO DEVELOP REALISTIC PARAMETERS FOR SPECIFICATION PURPOSES FOR THE APPLICATIONS OF OXYGEN TO MISSILES. THE SIGNIFICANCE, SOURCES, AND DEGREE OF CONTAMINATION, AND THE CURRENT SPECIFICATIONS FOR LIQUID OXYGEN AND EQUIPMENT ARE DISCUSSED. RECOMMENDATIONS FOR LIQUID OXYGEN SPECIFICATIONS AND FOR EQUIPMENT OPERATION ARE PRESENTED. AN EXTENSIVE BIBLIOGRAPHY IS INCLUDED, AS WELL AS APPENDICES WHICH AMPLIFY THE GENERAL DISCUSSION.

-PERTINENT FIGURES-

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MATERIALS FOR LUBRICATING AND SEALING PROPELLANT AND
HOT-GAS SYSTEMS

by

KERTTULA, JR. E. F.

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-ABSTRACT-

THIS REPORT IS INTENDED TO AID DESIGN PERSONNEL IN THE SELECTION OF LUBRICANTS AND THREAD SEALANTS FOR GASEOUS AND LIQUID O₂/H₂ SERVICE. THREAD LUBRICANTS, SEALANTS, AND THREADING COMPOUNDS LISTED IN THIS REPORT ARE THOSE MATERIALS WHICH ARE APPLIED TO CONNECTIONS OR THREADED FITTINGS FOR PREVENTING SEIZING OR GALLING DURING ASSEMBLY AND FOR MINIMIZING LEAKAGE IN USE. THREAD SEALANTS ARE DEFINED HEREIN AS MATERIALS WHICH DO NOT NORMALLY HARDEN OR SET AND ARE USED IN NONPERMANENT APPLICATIONS. THREADING COMPOUNDS ARE THOSE WHICH HARDEN AND ARE FOR USE ON PERMANENT-TYPE JOINTS. THREAD LUBRICANTS ARE FOR NONSEALING INSTALLATIONS. NATURALLY, THE FACTORS TO BE CONSIDERED IN THE FINAL SELECTION OF ANY MATERIAL ARE DEPENDENT UPON THE SERVICE INTENDED. SELECTION AND EVALUATION OF THESE FACTORS WILL VARY WIDELY. THUS, THIS REPORT DOES NOT ATTEMPT TO PROVIDE ALL INFORMATION NECESSARY TO FULLY ASSESS THE ADEQUACY OF A MATERIAL FOR SPECIFIC APPLICATIONS.

-PERTINENT FIGURES-

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SAFETY ASPECTS IN THE DESIGN AND OPERATION OF OXYGEN
SYSTEMS

by

REYNALES, C.H.

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-ABSTRACT-

THIS PAPER DEALS WITH THE BEHAVIOR AND PROPERTIES OF OXYGEN AS THEY APPLY TO SAFETY ASPECTS IN THE DESIGN AND OPERATION OF THE OXYGEN TRANSFER SYSTEM OF THE THOR MISSILE. THE PAPER SUMMARIZES THE FINDINGS OF A STUDY ON THE COMPATIBILITY OF MATERIALS WITH OXYGEN, LISTS THE RESULTS OF VARIOUS TESTS PERFORMED TO DETERMINE THE RESISTANCE OF MATERIALS AND CONTAMINANTS TO IGNITION IN AN OXYGEN ATMOSPHERE, AND REVIEWS THE OBSERVATIONS FROM A FIELD SURVEY MADE AMONG THE ORGANIZATIONS MOST ACTIVELY ENGAGED IN THE PRODUCTION AND USE OF OXYGEN. THE OVERALL CONCLUSION FROM THIS PROJECT IS THAT OXYGEN IS A POTENTIAL EXPLOSIVE WHICH SHOULD BE HANDLED WITH CARE. THERE ARE THREE BASIC ELEMENTS REQUIRED FOR COMBUSTION, ONE OF WHICH IS OXYGEN. THE OTHER TWO ARE THE COMBUSTIBLE MATERIALS AND THE SOURCES OF ENERGY NEEDED TO INDUCE A REACTION. UNTIL WE LEARN MORE ABOUT THE FIRST ELEMENT, OXYGEN, IT IS NECESSARY TO CONTROL THE OTHER TWO. THIS CAN BE DONE BY REDUCING OR ELIMINATING THE SOURCES OF ENERGY THROUGHOUT A SYSTEM AND BY A CLEANING AND MAINTENANCE PROGRAM AINED AT THE ELIMINATION AND AVOIDANCE OF CONTAMINANTS.

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HANDLING OF LOW-TEMPERATURE FLUIDS AND HIGH-PRESSURE OXYGEN

by

HIMMELBERGER, F.

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-ABSTRACT-

HAZARDS ASSOCIATED WITH CRYOGENIC FLUIDS ARE BROKEN DOWN INTO FOUR CATEGORIES, 1. PERSONNEL EXPOSURE TO EXTREME COLD OR TO INERT OR TOXIC GASES. 2. BRITTLZNESS OF STRUCTURAL MATERIALS AT LOW TEMPERATURES. (THIS MAY NOT BE A HAZARD IN ITSELF BUT CAN CONTRIBUTE TO PERSONNEL EXPOSURE OR TO THE FORMATION OF FLAMMABLE MIXTURES.) 3. HIGH PRESSURE ARISING FROM CONFINEMENT OF LIQUIDS AND GASES. 4. FLAMMABILITY CHARACTERISTICS. THIS PAPER CONCENTRATES ON NUMBER 4, SINCE THE ELIMINATION OF UNINTENTIONAL FLAMMABLE MIXTURES IS THE MOST SERIOUS PROBLEM.

-PERTINENT FIGURES-

FIG. 1 METHANE-OXYGEN-NITROGEN FLAMMABILITY LIMITS//FIG. 2 FLAMMABILITY AND DETONABILITY LIMITS - GASES//FIG. 3 SOLUBILITY OF HYDROCARBONS IN LIQUID OXYGEN//FIG. 4 CARBON ATOM CONTENT VERSUS SOLUBILITY FOR SATURATES//FIG. 5 ADIABATIC COMPRESSION TEMPERATURE//FIG. 6 ADSORPTION OF ETHYLENE, ETHANE AND METHANE//FIG. 8 FLAMMABLE LIMITS IN AIR

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SURVEY OF ACCIDENTS AT THE AIR SEPARATION PLANTS

-ABSTRACT-

A LARGE NUMBER OF ACCIDENTS WHICH OCCURRED IN AIR SEPARATION PLANTS IN JAPAN AND ELSEWHERE ARE ANALYZED. CLAUDE-TYPE, LINDE-TYPE, AND FRANKEL-TYPE SEPARATION PLANTS ARE DISCUSSED. ACCIDENTS WERE CLASSIFIED INTO EXPLOSIONS, BURSTING ACCIDENTS AND ACCIDENTS IN WHICH HUMANS WERE INJURED OR KILLED. VARIOUS ACCIDENT MODES ARE ANALYZED, AND THE SUCCESS OF APPROPRIATE COUNTERMEASURES IS DESCRIBED. DATA ON ALL AIR SEPARATION PLANTS IN JAPAN ARE GIVEN. MANY SAFETY RECOMMENDATIONS ARE GIVEN THROUGHOUT THE REPORT.

-PERTINENT FIGURES-

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-ABSTRACT-

THE SIMULTANEOUS PRODUCTION OF HIGH PURITY OXYGEN, NITROGEN, AND ARGON IS OFTEN REQUIRED FROM AIR SEPARATION PLANTS TO MEET TODAY'S NEEDS OF THE MILITARY, SPACE, AND COMMERCIAL MARKETS. DETAILED PRODUCT SPECIFICATIONS AS DEVELOPED BY THE VARIOUS SEGMENTS OF THE INDUSTRY ARE PRESENTED TOGETHER WITH ACTUAL PLANT PERFORMANCE DATA. GAS CHROMATOGRAPHY IS USED TO MEASURE INDIVIDUAL COMPONENT IMPURITIES IN OXYGEN AND TO MONITOR HYDROCARBON CONTENT AT VARIOUS LOCATIONS WITHIN THE PLANT.

-PERTINENT FIGURES-

TAB. 1 TYPICAL HIGH PURITY PRODUCT SPECIFICATIONS PAGE 10//TAB. 3
GAS CHROMATOGRAPHIC ANALYSIS PAGE 12

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SAFETY PRECAUTIONS WITH RESPECT TO HYDROCARBONS IN AIR
FRACTIONATING APPARATUS (SCHUTZMASSNAHMEN GEGEN
KOHLENWASSERSTOFFE IM LUFTTRENNER)

by

KARWAT, E.

11/00/60

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OF POOR QUALITY

SECURITY CLASS
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-ABSTRACT-

THIS REPORTS THE INVESTIGATION OF AN EXPLOSION IN THE LINDE-FRAENKL APPARATUS IN AN AIR SEPARATION PLANT. THE EXPLOSION TOOK PLACE WHEN LIQUID OXYGEN FROM THE ACETYLENE SEPARATOR WAS DISCHARGED. PREVIOUS TESTS SHOWED THAT THE ACETYLENE CONTENT OF THE STREAM WAS LESS THAN 0.01 PPM SO THAT THE EXPLOSION MUST HAVE BEEN CAUSED BY OTHER HYDROCARBONS. IT APPEARS THAT THE PROPYLENE PRESENT IN THE STREAM PREVENTS THE SORPTION OF ETHANE AND IMPAIRS THE SORPTION OF PROPANE AND ETHYLENE. THE AUTHOR RECOMMENDS - 1) MORE VIGOROUS FLUSHING OF THE AUXILIARY VAPORIZER, WITH THE RETURN OF THE OVERFLOW LIQUID THROUGH THE ADSORBER PLACED AHEAD OF THE AUXILIARY VAPORIZER. 2) SCRUBBING OUT OF THE HYDROCARBONS FROM THE AIR WITH THE SMALLEST POSSIBLE AMOUNT OF LIQUID AIR BEFORE ITS ENTRANCE INTO THE COLUMN. 3) ADSORPTION OF THE HYDROCARBONS FROM THE GASEOUS AIR BETWEEN THE REGENERATOR AND THE COLUMN. 4) REGENERATIVE ADSORPTION/DESCRIPTION OF THE AIR ON A SORBENT LAYER PLACED AT THE COLD END OF THE REGENERATOR. 5) BURNING OF THE HYDROCARBONS BEFORE THE AIR ENTERS THE FRACTIONATOR. THE PAPER INCLUDES DETAILS FOR IMPLEMENTING THE RECOMMENDATIONS.

-PERTINENT FIGURES-

FIG. 1 ADSORPTION OF VARIOUS HYDROCARBONS ON SILICA GEL FROM THEIR SOLUTION IN LIQUID OXYGEN, PAGE 13//FIG. 2 FLUCTUATIONS IN THE PROPANE CONTENT OF THE LIQUID IN THE PRESSURE COLUMN AND IN THE MAIN CONDENSER, PAGE 14//FIG. 3 ADSORBER FOR THE OVERFLOW LIQUID FROM THE AUXILIARY VAPORIZER, PAGE 15//FIG. 4 TEMPERATURE CHANGES IN THE GEL LAYER REGENERATOR, PAGE 16

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CORPORATE SOURCE -

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keys 9109 through 9110

THE DETERMINATION OF TRACE IMPURITIES IN LIQUID OXYGEN FOR
BREATHING BY INFRA-RED METHODS

by

CORBETT, J. K.

10/00/67

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-ABSTRACT-

A DOUBLE-BEAM INFRA-RED SPECTROPHOTOMETER HAS BEEN MODIFIED BY THE ADDITION OF A PAIR OF 40 METRE LONG-PATH CELLS AND ORDINATE SCALE EXPANSION TO MAKE POSSIBLE THE DETECTION AND QUANTITATIVE DETERMINATION OF TRACES OF IMPURITIES IN LIQUID OXYGEN FOR BREATHING. THE EFFECTS OF PRESSURE BROADENING ARE CONSIDERED AND THE LOWER LIMITS OF DETECTION ARE LISTED FOR THE IMPURITIES DETERMINED. THIS SPECTROPHOTOMETER PROVIDES AN ACCURATE AND RAPID METHOD FOR THE DETERMINATION OF THE TRACE IMPURITIES IN LIQUID OXYGEN FOR BREATHING TO AIR STANDARD 14/9A. ONLY INFRARED INACTIVE MOLECULES SUCH AS NITROGEN, HELIUM, ARGON, ETC. ARE INCAPABLE OF DETECTION BY THE METHOD DESCRIBED.

-PERTINENT FIGURES-

TAB.1 SPECTROSCOPIC DATA FOR IMPURITIES, PAGE 4//TAB.2 PRESSURE BROADENING OF A CONSTANT PARTIAL PRESSURE OF ETHYLENE, PAGE 5//TAB.3 PRESSURE SENSITIVITY, PAGE 6//TAB.6 CALIBRATION DATA FOR GASES, PAGE 10//TAB.9 MINIMUM DETECTION LIMITS, PAGE 13//TAB.10 CONCENTRATIONS OF IMPURITIES FOUND IN OXYGEN, PAGE 14

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LIQUID PROPELLANT GAS ABSORPTION STUDY, FINAL SUMMARY TECH.
REPT. COVERING PERIOD 24 JUL 1967-24 JUN 1968

by

CANNON, W.A.
ROBSON, J.H.
ENGLISH, W.D.

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-ABSTRACT-

THIS FINAL TECHNICAL REPORT SUMMARIZES THE STUDIES CONDUCTED ON THE SOLUBILITIES OF PRESSURANT GASES HELIUM AND NITROGEN IN THE LIQUID PROPELLANTS FLUORINE, FLOX, OXYGEN, OXYGEN DIFLUORIDE, DIOXYGEN DIFLUORIDE, NITROGEN TRIFLUORIDE, TETRAFLUOROHYDRAZINE, CHLORINE TRIFLUORIDE, CHLORINE PENTAFLUORIDE, ETHANE, ETHYLENE, PROPANE, DIBORANE, TRIMETHYLBORANE, NITRIL FLUORIDE, PERCHLORYL FLUORIDE, AND AMMONIA. HELIUM SOLUBILITIES WERE MEASURED FOR ALL PROPELLANTS, BUT ONLY A FEW COMBINATIONS WERE USED WITH NITROGEN. MEASUREMENTS WERE MADE AT TWO PRESSURES, 300 AND 700 PSIG, AND AT SEVERAL APPROPRIATE TEMPERATURES COVERING A RANGE ABOVE AND BELOW THE NORMAL BOILING POINT WHEREVER POSSIBLE. SAMPLES WERE TAKEN FROM CAREFULLY EQUILIBRATED, AGITATED SYSTEMS, AND ANALYSES WERE CONDUCTED BY GAS CHROMATOGRAPHY. THE GAS CHROMATOGRAPHIC ANALYSES OF THE HIGH ENERGY PROPELLANTS REQUIRED THE APPLICATION OF SEVERAL UNCONVENTIONAL TECHNIQUES. THESE INCLUDED (1) USE OF OXYGEN AS A CARRIER GAS, AND (2) COMPLETE ABSORPTION OF THE PROPELLANT ON THE COLUMN TO PREVENT ATTACK ON THE DETECTOR SENSORS, YET PERMITTING ELUTION OF OTHER COMPONENTS, INCLUDING THE PRESSURANT GAS, FOR ACCURATE ANALYSES.

-PERTINENT FIGURES-

TAB.2 SOLUBILITY OF HELIUM AND NITROGEN IN LIQUID OXYGEN DIFLUORIDE, PAGE 24//TAB.5 SOLUBILITY OF HELIUM IN LIQUID FLUORINE, PAGE 30//TAB.7 SOLUBILITY OF HELIUM IN LIQUID 70-FLOX, PAGE 33//TAB.9 SOLUBILITY OF HELIUM IN LIQUID OXYGEN, PAGE 36//TAB.11 SOLUBILITY OF HELIUM AND NITROGEN IN LIQUID ETHYLENE, PAGE 39//TAB.15 SOLUBILITY OF HELIUM IN LIQUID DIOXYGEN DIFLUORIDE, PAGE 49

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YORK, N. Y., 1941

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CORPORATE SOURCE -

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AVIATORS BREATHING OXYGEN FROM AIRCRAFT CONVERTERS,
EVALUATION OF

-ABSTRACT-

TWO SAMPLES OF AVIATORS BREATHING OXYGEN WERE ANALYZED FOLLOWING AN ACCIDENT IN WHICH A PILOT WAS KILLED. THE LIQUID OXYGEN HAD BEEN OBTAINED FROM THE AIRCRAFT CARRIER USS BENNINGTON. THE SAMPLES WERE TAKEN FROM LOX CONVERTERS OF AIRCRAFT WHICH HAD OBTAINED LOX FROM THE BENNINGTON AT THE SAME TIME AS THE AIRCRAFT INVOLVED IN THE FATAL CRASH. THE SAMPLES CONTAINED CONTAMINANTS FAR IN EXCESS OF THE MAXIMUMS ALLOWED UNDER SPECIFICATIONS. PILOT COMPLAINTS OF BAD ODORS, HEADACHES, NAUSEA, AND LOSS OF COORDINATION WERE ATTRIBUTED TO THE OXYGEN SUPPLY. IT IS SUGGESTED THAT THE TOXIC EFFECTS OF THE CONTAMINANTS MIGHT BE ENHANCED WHEN BREATHING PURE OXYGEN. IN ADDITION, ONE SAMPLE CONTAINED ACETYLENE IN EXCESS OF ITS SOLUBILITY IN LOX, CONSTITUTING AN EXPLOSIVE HAZARD. THE REPORT RECOMMENDS THAT MEANS OF MONITORING CONTAMINANT LEVELS IN LOX BE PROVIDED TO AIRCRAFT CARRIERS AND ALL LAND-BASED PLANTS WHICH DO NOT HAVE SUCH INSTRUMENTATION. A SUGGESTED INSTRUMENT IS A GAS CHROMATOGRAPH SUCH AS THE NRL TOTAL HYDROCARBON ANALYZER.

-PERTINENT FIGURES-

TAB. ANALYTICAL DATA FOR OXYGEN SAMPLES FROM AIRCRAFT CONVERTERS,
PAGE 5

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DEVELOPMENT OF VULCANIZABLE ELASTOMERS SUITABLE FOR USE IN
CONTACT WITH LIQUID OXYGEN. ANNUAL SUMMARY REPORT, JUNE
1967-MAY 1968

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by

WARNER, D.A.

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-ABSTRACT-

HOMOPOLYMERS HAVE BEEN PREPARED AND THEIR LOW TEMPERATURE TENSILE PROPERTIES STUDIED. INCREASING VALUES OF N WERE FOUND TO BRING ABOUT INCREASING ELONGATIONS AND DECREASING TENSILE STRENGTH AND TOUGHNESS. ATTEMPTS TO PREPARE COPOLYMERS WITH VINYLIDENE FLUORIDE WERE UNSUCCESSFUL. ATTEMPTS TO PREPARE CYCLOPOLYMERS OF PERFLUOROGLUTARALDEHYDE, PERFLUOROGLUTARYL FLUORIDE, AND PERFLUORO-3-OXAHEPTADIENE-1,6 WERE UNSUCCESSFUL. POLYANHYDRIDES OF FLUOROCARBON DICARBOXYLIC ACIDS WERE FOUND TO BE HYDROLYTICALLY UNSTABLE. POLYCONDENSATION OF PERFLUOROALDEHYDE HYDRATES WITH FLUOROCARBON DICARBOXYLIC ACIDS DID NOT PRODUCE THE EXPECTED LINEAR POLYESTERS. WORK WAS BEGUN ON THE PREPARATION OF ESTERS DERIVED FROM OLIGOMERS OF HEXAFLUOROPROPYLENE OXIDE.

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NEW DATA ON THE EXPLOSIVENESS OF LIQUID OXYGEN AND
HYDRO-CARBONS (RUSSIAN)

by

GITTSEVICH, G. A.
BASYROV, Z. B.
SAGAIDAK, V. J.

00/00/59

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U/Unrestricted	Unlimited	Incremental	Acceptable

-ABSTRACT-

EXPERIMENTS SHOWED THAT THE HEATING OF CYLINDER OIL, UNDER PRESSURE IN AIR, PRODUCES LOW-BOILING LIQUID AND GASEOUS HYDROCARBONS AND COKE, THE PRODUCTS OF THERMAL CRACKING. THESE PRODUCTS, MIXED WITH LIQUID OXYGEN, WERE TESTED FOR EXPLOSION SENSITIVITY, AND WERE FOUND TO BE MORE SENSITIVE TO IMPACT THAN NITROGLYCERINE. THE DATA SHOW THAT ACETYLENE SHOULD NOT BE CONSIDERED THE ONLY CAUSE OF EXPLOSIONS IN AIR SEPARATION EQUIPMENT. PRODUCTION OF SPARKING GASES IN RECIPROCATING COMPRESSORS, AND THEIR CONDENSATION WITH OXYGEN IN AIR SEPARATION EQUIPMENT, CAN EXPLAIN EXPLOSIONS IN CASES WHERE ACETYLENE AND LUBRICATING OIL WERE NOT FOUND. CLEANING OF THE PROCESS AIR, WITH REMOVAL OF ALL OILS AND OTHER HYDROCARBONS, CAN INSURE SAFE OPERATION OF AIR SEPARATION EQUIPMENT.

-PERTINENT FIGURES-

TAB. 1 COMPOSITION OF GASES OBTAINED BY THERMAL CRACKING OF OIL P-28 AT TEMPERATURES OF 200 AND 350 C, PAGE 14//TAB. 2 MINIMUM PRESSURE OF RUPTURE OF DIAPHRAGMS NECESSARY TO PRODUCE EXPLOSIONS IN VARIOUS MIXTURES, PAGE 15

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A STUDY OF TRACE IMPURITIES IN AVIATORS BREATHING OXYGEN

by

DREW, C.M.
SCHOWEN, R.L.
SMITH, S.R.

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-ABSTRACT-

A STUDY OF AVIATORS BREATHING OXYGEN FROM PRESSURE AND LIQUID APPARATUS HAS BEEN CARRIED OUT TO DETERMINE THE IMPURITIES THAT ARE RESPONSIBLE FOR NAUSEA AND ANOXIATION REPORTED BY SOME PILOTS. AN ANALYTICAL METHOD USING GAS CHROMATOGRAPHY AND MASS SPECTROMETRY HAS BEEN USED TO DETERMINE THE IDENTITY AND CONCENTRATION OF THE CONTAMINANTS IN THE BREATHING OXYGEN. A POSSIBLE MECHANISM WHEREBY THESE CONTAMINANTS AFFECT THE PILOTS HAS BEEN PROPOSED AND RECOMMENDATIONS TO PURIFY THE BREATHING OXYGEN HAVE BEEN MADE. THE REPORT CONCLUDES WITH A NUMBER OF RECOMMENDATIONS MOSTLY CENTERING AROUND PURGING OF THE STORAGE TANKS, TRANSFER CARDS AND MOST ESPECIALLY THE CONVERTER TANKS IN THE AIRCRAFT. THE USE OF ABSORBENTS IN THE LOW PRESSURE FEED LINES IN THE AIRCRAFT IS ALSO RECOMMENDED.

-PERTINENT FIGURES-

FIG.2 RUN NO. 501 LIQUID OXYGEN FROM CONVERTER, PAGE 13//FIG.3 RUN NO. 503 STORAGE TANK NO. 1, PAGE 14//FIG.4 RUN NO. 504 GAS FROM CONVERTER, PAGE 15// FIG.7 RUN NO. 507 NEWLY REFILLED STORAGE TANK, PAGE 18//FIG.8 RUN NO. 508 OXYGEN LIQUEFIED FROM CYLINDER, PAGE 19//TAB.1 ANALYSIS OF OXYGEN SAMPLES, PAGES 24-26

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CORPORATE SOURCE -

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SURVEY OF CONTAMINATION IN ROCKET PROPULSION FLUID SYSTEMS

by

TELLIER, G.F.
LEWELLEN, J.W.
SIANDKE, H.

11/00/67

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U/Other	Govt. Only	Summary	Acceptable

-ABSTRACT-

THIS REPORT PRESENTS THE PHASE I SURVEY RESULTS OF A PROGRAM TO GENERATE DESIGN CRITERIA FOR VALVE POPPETS AND SEATS CAPABLE OF SEALING RELIABLY IN THE CONTAMINATION ENVIRONMENT PRESENT IN ROCKET PROPULSION FLUID SYSTEMS. THE PURPOSE OF THE SURVEY WAS TO QUANTITATIVELY AND QUALITATIVELY DESCRIBE CONTAMINANTS (PRIMARILY PARTICULATES) OCCURRING IN THESE SYSTEMS. A COMPREHENSIVE LITERATURE SEARCH YIELDED CONSIDERABLE GENERALIZED INFORMATION ON CONTAMINATION DESCRIPTION WITH RESPECT TO TYPES, SOURCES, AND CONTROL. ADDITIONALLY, EXTENSIVE LITERATURE ON PARTICLE SIZE ANALYSIS AND GRAPHICAL DISPLAY WAS OBTAINED. THESE TWO CATEGORIES OF INFORMATION ARE SUMMARIZED AND A SUBJECT CATEGORIZED BIBLIOGRAPHY OF 209 ANNOTATED REFERENCES IS PRESENTED. A SURVEY OF ORGANIZATIONS ASSOCIATED WITH LIQUID ROCKET PROPULSION WAS PERFORMED FROM WHICH NUMEROUS SPECIFICATIONS AND TYPICAL CONTAMINATION DATA FOR A VARIETY OF FLUIDS, CONDITIONS, AND LOCATIONS WERE OBTAINED. THESE DATA, AS COMPILED AND TABULARLY PRESENTED, REPRESENT A BROAD SPECTRUM OF FLUID SYSTEM CONTAMINATION. THEY DO NOT, HOWEVER, SPECIFICALLY DEFINE CONTAMINATION IN OPERATING LIQUID ROCKET SYSTEMS. THIS RESULTS FROM EXTREME DIFFICULTIES IN OBTAINING REPRESENTATIVE SAMPLES AND MAKING ACCURATE MEASUREMENTS. THE REPORT REALLY IS A SURVEY, BUT IT DOES GIVE VARIOUS CLEANLINESS CRITERIA AND STANDARDS AS WELL AS CONTAMINATION DATA.

-PERTINENT FIGURES-

FIG. B-6 PARTICLE COUNT LIMITS FOR SPACE ENGINES PER ROCKETDYNE SPECIFICATION RA0615-003, PAGE 191//FIG. B-10 PARTICLE COUNT LIMITS FOR APOLLO SPACECRAFT DELIVERED PROPELLANTS PER NASA MSC-SPEC-3-6, PAGE 195// FIG. B-11 PARTICLE COUNT LIMITS AND DATA FOR APOLLO - SATURN, LM-RCS FROM NASA, KSC, PAGE 196//FIG. B-12 PARTICLE COUNT DATA FOR APOLLO - SATURN LM-RCS FROM NASA, KSC, PAGE 197//FIG. B-13 PARTICLE COUNT LIMITS AND DATA FOR APOLLO - SERVICE PROPULSION SYSTEM, PAGE 198//FIG. B-18 PARTICLE COUNT LIMITS AND DATA FOR P-1 ENGINE GIMBAL SYSTEM, PAGE 203

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PROCESS FOR DEMETHANIZATION OF LIQUID OXYGEN

by

SAVAGE, D.W.

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-ABSTRACT-

THE DISCLOSURE IS DIRECTED TO AN IMPROVED PROCESS FOR THE REMOVAL OF METHANE FROM A MIXTURE OF METHANE AND OXYGEN BY THE USE OF AN X-TYPE ZEOLITE CATALYST. THE USE OF SILVER AND CALCIUM CATION-EXCHANGED FORMS OF SYNTHETIC X ZEOLITES RESULT IN A MUCH HIGHER CAPACITY FOR METHANE REMOVAL THAN WAS HERETOFORE POSSIBLE UNDER THE PRIOR ART.

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keys 14946 through 14948

EVALUATION OF USED LOX PUMP OIL (NU-TROL, MARK II), NU-CHEM
INDUSTRIES, SHARPES, FLA.

by

WALTERS, G. L.

05/18/71

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Acceptable

-ABSTRACT-

THIS REPORT PRESENTS RESULTS OF AN EXAMINATION OF SIX SAMPLES OF USED LOX PUMP OIL. THE TESTS SHOWED NO BREAKDOWN OF CONSTITUENTS TO FORM FREE ACID, BUT THERE WERE AGGREGATES OF TEFLON PARTICLES SUGGESTING PRELIMINARY CHANGES. SOME OF THE OIL SHOWED LARGE AMOUNTS OF AGGREGATION FOR SHORT RUNNING TIMES, AND IT IS SUGGESTED THAT THE ALUMINUM PUMP HOUSING IS AIDING THE PROCESS. IT IS NOTED THAT THIS OIL HAS BEEN FOUND TO DETONATE WITH ALUMINUM UNDER SHEARING CONDITIONS. RESULTS OF ANALYSIS OF WEAR METALS IN THE OILS AND OF 4-BALL WEAR TESTS ARE ALSO PRESENTED.

-PERTINENT FIGURES-

TAB.1 WEAR METAL ANALYSIS, PAGE 3/TAB.2 4-BALL WEAR TEST RESULTS,
PAGE 4

-SOURCE INFORMATION-

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THE DETERMINATION OF HYDROCARBON TRACES IN ATMOSPHERIC AIR
AND LIQUID OXYGEN

by

THEER, J.

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-ABSTRACT-

FOR A LONG TIME A RAPID METHOD OF DETERMINING TRACES OF HYDROCARBONS IN THE AIR SUCKED INTO AND THE LIQUID OXYGEN PRODUCT OF AIR SEPARATION PLANTS HAS BEEN SOUGHT. THIS IS NEEDED TO AVOID DANGERS OF EXPLOSIONS DUE TO THE ACCUMULATION OF HYDROCARBONS ESPECIALLY ACETYLENE. THIS PAPER DESCRIBES A GAS CHROMATOGRAPH WITH A MICROFLAME IONIZATION DETECTOR. A 10 ML SAMPLE CAN BE PROCESSED IN 5 MINUTES WITH A SENSITIVITY OF 5 PARTS PER MILLION AND IN 15 MINUTES A SENSITIVITY OF 10 PARTS PER BILLION CAN BE ACHIEVED. THE SAMPLER AND INSTRUMENT HAVE BEEN TESTED IN CONTINUOUS OPERATION.

-PERTINENT FIGURES-

TAB. P.6 HYDROCARBON CONTENT OF ATMOSPHERIC AIR FROM VARIOUS REGIONS OF GERMAN DEMOCRATIC REPUBLIC//FIG.3 HYDROCARBON CHROMATOGRAM FOR LIQUID OXYGEN, PAGE 7//FIG.4 CONCENTRATION APPARATUS FOR HYDROCARBONS FROM ATMOSPHERIC AIR, PAGE 8//FIG.5 HYDROCARBON CHROMATOGRAM FOR ATMOSPHERIC AIR, PAGE 7

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COMPOSITION CHANGES IN LIQUID OXYGEN AS A RESULT OF
EVAPORATION AND RELATION TO FUEL-CELL OPERATION

by

EASTER, R.W.

01/00/73

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-ABSTRACT-

EVAPORATION OF LIQUID OXYGEN LEADS TO CHANGES IN COMPOSITION BECAUSE OF DIFFERENCES BETWEEN THE VOLATIBILITY OF OXYGEN AND THE VOLATIBILITY OF IMPURITIES. AN EXPRESSION IS PRESENTED WHICH MAY BE USED TO ESTIMATE CHANGES IN COMPOSITION AS A CONSEQUENCE OF EVAPORATION DURING THE STORAGE OF LIQUID OXYGEN. THE SENSITIVITY OF FUEL-CELL SYSTEMS TO SUCH CHANGES IS DISCUSSED, AND SAMPLE CALCULATIONS ARE PRESENTED. SAMPLE CALCULATIONS ARE CARRIED OUT FOR PROPELLANT GRADE LIQUID OXYGEN, AND THE LIKELIHOOD AND EFFECT OF COMPOSITION CHANGES IN REFERENCE TO FUEL CELL SYSTEM OPERATION ARE DISCUSSED. THE SPECIFIC IMPURITIES INCLUDE CARBON DIOXIDE, METHANE, KRYPTON, NITROGEN AND ARGON. THE AUTHORS CONCLUDE THE OBVIOUS - THAT LIQUID WITHDRAWAL IS BEST AND THIS POINTS TO SUPERCRITICAL STORAGE.

-PERTINENT FIGURES-

TAB.I INITIAL LIQUID-OXYGEN IMPURITY LEVELS USED IN SAMPLE CALCULATIONS, PAGE 13//TAB.VIII EXPRESSIONS USED IN CASE 3 CALCULATIONS, PAGE 14//TAB.IX LIQUID-OXYGEN STORAGE MODES, PAGE 15//FIG.2 CONCENTRATION CHANGES IN PROPELLANT-GRADE LIQUID OXYGEN AS CONSEQUENCE OF EVAPORATION, PAGE 16// FIG.3 CONCENTRATION CHANGES IN PROPELLANT-GRADE LIQUID OXYGEN AS CONSEQUENCE OF EVAPORATION (3 ATMOSPHERES PRESSURE), PAGE 17//FIG.4 WITHDRAWAL PROFILE FOR CASE 3, PAGE 18

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HAZARDS OF CRYOGENIC SYSTEMS (LKS* PART 1 OF 3.)

by

VAN DYKE, B.H.

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-ABSTRACT-

THE VAST GROWTH OF INDUSTRIES PRODUCING CRYOGENIC FLUIDS WITH THE ATTENDANT MORE COMPLEX PROCESSING SYSTEMS IS CITED. THE IMPORTANCE OF ACCURATE ANALYSIS FOR, AND MINIMIZING OF CONTAMINANTS IN FUEL AND OXIDIZER PROCESS STREAMS IS STRESSED. APPROXIMATELY 15 DIFFERENT ACCIDENTS IN HYDROGEN AND OXYGEN SYSTEMS, AND AIR SEPARATION PLANTS ARE BRIEFLY REPORTED. A BRIEF ANALYSIS FOR THE POSSIBLE CAUSES OF EACH IS GIVEN. THE VARIOUS ACCIDENTS CITED WERE BELIEVED CAUSED BY BRITTLE FRACTURE OF METALS, OIL OR OIL VAPORS MIXED WITH OXYGEN ENRICHED ATMOSPHERES, CONTAMINANTS AND CONTAMINANT CONCENTRATIONS IN HIGH PRESSURE OXYGEN SYSTEMS, SMOKING IN OXYGEN ENRICHED ATMOSPHERES, POOR OPERATING PROCEDURES, AND VALVE ACTUATION IN HIGH PRESSURE OXYGEN SYSTEMS. EACH ACCIDENT IS ONLY BRIEFLY EXPLAINED ALONG WITH THE POSSIBLE CAUSES OF EACH, BUT THE MORE PREVALENT CAUSES OF ACCIDENTS IN OXYGEN AND HYDROGEN SYSTEMS ARE CLEARLY POINTED OUT.

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INVESTIGATION OF REACTIVITY OF LAUNCH VEHICLE MATERIALS
WITH LIQUID OXYGEN, QUARTERLY REPORT NO. 3/ OCT 23, 1968 TO
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by

MILL, T.
CHAMBEPLAIN, D.L.
STRINGHAM, R.S.
KIRSHEN, N.A.
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-ABSTRACT-

A SELECTED GROUP OF ORGANIC COMPOUNDS WERE IMPACT TESTED WITH THE ASMA DROP-WEIGHT TESTER DURING THIS REPORT PERIOD. ATTEMPTS WERE MADE TO CORRELATE THE IMPACT SENSITIVITIES OF THESE COMPOUNDS WITH THEIR PHYSICAL PROPERTIES AND CHEMICAL STRUCTURE. IN SOME INSTANCES SUBGROUPS OF COMPOUNDS THAT ARE RELATED BY THEIR CHEMICAL STRUCTURE HAVE EXHIBITED SENSITIVITIES CORRELATING WITH THEIR FLASH POINTS. CHEMICAL STRUCTURE HAS ALSO BEEN SHOWN TO BE A FACTOR IN IMPACT SENSITIVITY. THE IMPACT SENSITIVITIES OF COMENE, TOLUENE, AND T-ETHYLBENZENE ARE IN THE SAME ORDER AS THEIR REACTIVITIES TOWARD PEROXY RADICALS IN OXIDATION. A FEW OF THE COMPOUNDS THAT WERE IMPACT TESTED WERE IGNITED BY THE HOT-WIRE METHOD, AND MINIMUM IGNITION TEMPERATURES AND IGNITION-DELAY TIMES WERE MEASURED. THE HOT-WIRE SENSITIVITY OF COMPOUNDS WITHIN CERTAIN SUBGROUPS WERE AGAIN FOUND TO CORRELATE WITH THE EASE OF HOT-WIRE IGNITION. FURTHERMORE, HOT-WIRE DATA APPEAR TO AGREE WITH IMPACT DATA. TWO PRELIMINARY EXPERIMENTS LEADING TO THE USE OF HIGH-SPEED PHOTOGRAPHY FOR THE STUDY OF IMPACT-INDUCED IGNITION MECHANISMS WERE PERFORMED.

-PERTINENT FIGURES-

TAB.1 IMPACT SENSITIVITY VERSUS PHYSICAL PROPERTIES FOR PURE ORGANIC COMPOUNDS, PAGE 6//TAB.2 COMPARISON OF IMPACT AND HOT-WIRE SENSITIVITY DATA, PAGE 9//TAB.3 REACTION OF OXYGEN WITH ME(6)AL(2) IN CF(2)CI(2), PAGE 13

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(1968)//QUARTERLY PROGRESS REPORT NO. 2, INVESTIGATION OF REACTIVITY OF LAUNCH VEHICLE MATERIALS WITH LIQUID OXYGEN, SRI PROJECT PRU-7228, CONTRACT NO. NAS8-21316, NOVEMBER 12, 1968// REPORT NO. 3, INVESTIGATION OF REACTIVITY OF LAUNCH VEHICLE MATERIALS WITH LIQUID OXYGEN, SRI PROJECT PRU 7228, CONTRACT NO. NAS8-21316, SEPTEMBER 12, 1968//A.G. DAVIES AND B.P. ROBERTS, J. CHEM. SOC. (B), 1074 (1968)//J.A. HOWARD, K.U. INGOLD, AND M. SYMONDS, CAN. J. CHEM., 46, 1017 (1968)//L. HORNER AND W. JURGELEIT, ANN. CHEM., 591, 138 (1955)

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II. REACTION CHARACTERISTICS OF ORGANIC COMPOUNDS WITH OXYGEN

FIRE AND EXPLOSION HAZARDS OF FLIGHT VEHICLE COMBUSTIBLES

by

LITCHFIELD, E. L.

PERLFE, H. E.

03/00/65

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-ABSTRACT-

SEVERE EXPLOSION HAZARDS COULD RESULT FROM A MASSIVE SPILL OF NON-HYPERGOLIC FUEL AND OXIDIZER OF A MISSILE PROPULSION SYSTEM. THIS PROBLEM WOULD BE ESPECIALLY SEVERE WITH THE HIGH-ENERGY SYSTEMS WHERE ONE OR BOTH OF THE PROPELLANT COMPONENTS ARE CRYOGENS. THE SENSITIVITY OF TWO SUCH SYSTEMS, LIQUID HYDROGEN PLUS SOLID OXYGEN PLUS DILUENT AND LIQUID OXYGEN PLUS SOLID HYDROCARBON PLUS DILUENT, HAS BEEN INVESTIGATED EMPLOYING A PROJECTILE IMPACT TO DETERMINE THE SHOCK REQUIRED TO DETONATE THESE MIXTURES. WITH NO DILUENT, EACH EXPLOSIVE SYSTEM IS INITIATED BY A SHOCK STIMULUS OF 1.0 TO 2.5 KBAR. THE EXPLOSIVE YIELDS ARE SUCH THAT 1-LB CRYOGENIC MIXTURE IS EQUIVALENT TO 0.6 TO 2.0 LB TNT. SODIUM CHLORIDE, NITROGEN, AND METHYL CHLORIDE HAD INERT DESENSITIZING EFFECTS UPON THE LIQUID HYDROGEN MIXTURES BUT DID NOT REDUCE THE EXPLOSIVE YIELD. SODIUM CHLORIDE AND NITROGEN DESENSITIZED THE LIQUID OXYGEN SYSTEM, SODIUM CHLORIDE OR WATER REDUCED THE EXPLOSIVE YIELD OF THIS SYSTEM. LARGE VOLUMES OF DETONABLE, GASEOUS HYDROGEN-OXYGEN MIXTURES WOULD RESULT FROM A MASSIVE SPILL OF LIQUID HYDROGEN-LIQUID OXYGEN. INHIBITION OF DETONATION INITIATION BY DRY POWDER PARTICLE ADDITIVES WAS INVESTIGATED. THE POWDER ADDITIVES PRODUCED INSIGNIFICANT INHIBITION IN COMPARISON TO THAT PRODUCED BY GASEOUS DILUENTS. FLAMMABILITY LIMIT DETERMINATIONS OF FOUR ADDITIONAL HALOGENATED HYDROCARBONS ARE INCLUDED IN A DISCUSSION OF THE CHARACTERISTICS OF 10 SUCH COMPOUNDS. MOST OF THE COMPOUNDS WERE FLAMMABLE IN OXYGEN ATMOSPHERES AT TEMPERATURES BELOW 200 DEGREES F, THEIR COMBUSTION PRODUCTS INCLUDED TOXIC HALOGENS OR HALOGEN HALIDES.

-PERTINENT FIGURES-

FIG. 1 TYPICAL PRESSURE HISTORY RECORD OBTAINED DURING COMBUSTION OF 50 VOLUME PERCENT CF(2)BR(2) IN AN OXYGEN ATMOSPHERE IN A 1-FOOT DIAMETER SPHERE, PAGE 23//FIG. 2 APPARATUS USED TO MEASURE MAXIMUM EXPLOSION PRESSURES DURING COMBUSTION OF CONFINED GAS MIXTURES, PAGE 24//TAB. 1 PROJECTILE IMPACT SENSITIVITY OF LH(2) PLUS O(2) PLUS DILUENT, PAGE 5//TAB. 2 PROJECTILE IMPACT SENSITIVITY OF LO(2) PLUS SOLID HYDROCARBON PLUS DILUENT, PAGE 6//TAB. 3 MINIMUM AUTOIGNITION TEMPERATURES (DEGREE F)(2) OF

HALOGENATED HYDROCARBONS IN VARIOUS OXIDANT ATMOSPHERES AT ATMOSPHERIC PRESSURE IN A 250-CC GLASS VESSEL, PAGE 14//TAB.4 YIELD OF CARBON DIOXIDE IN AN OXYGEN ATMOSPHERE AT VARIOUS TEMPERATURES FOR A REACTION PERIOD OF ONE MINUTE IN A GLASS VESSEL, PAGE 16//TAB.5 LIMITS OF FLAMMABILITY OF VARIOUS HALOGENATED HYDROCARBONS (VOLUME PERCENT) IN GLASS AND STAINLESS STEEL, PAGE 16//TAB.6 LIMITS OF FLAMMABILITY OF VARIOUS HALOGENATED HYDROCARBONS (VOLUME PERCENT) IN AIR, OXYGEN AND NITROGEN TETROXIDE ATMOSPHERES IN GLASS VESSELS, PAGE 17//TAB.7 MAXIMUM PRESSURES, RATES OF PRESSURE RISE AND BROMINE CONCENTRATIONS DEVELOPED DURING COMBUSTION OF FIVE HALOGENATED HYDROCARBONS IN OXYGEN AND AIR ATMOSPHERES, PAGE 18.

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SAFETY OF MATERIALS IN CONTACT WITH LIQUID OXYGEN

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-ABSTRACT-

TEST METHOD AND APPARATUS AND TEST RESULTS OF IMPACT SENSITIVITY OF VARIOUS MATERIALS IN LIQUID OXYGEN ARE PRESENTED. ALSO PRESENTED ARE AN ABSTRACT OF A PAPER ON BEHAVIOR OF LIQUID OXYGEN AND A LITERATURE SURVEY OF REACTIONS OF ORGANIC MATERIALS WITH LIQUID OXYGEN. CONCLUSION IS THAT MOST REDUCING AGENTS AND HYDROCARBONS IN CONTACT WITH LIQUID OXYGEN CONSTITUTE A POTENTIAL EXPLOSIVE HAZARD.

-PERTINENT FIGURES-

DRAWING IMPACT TESTER PAGES 17-26//TABLE 1 IMPACT SENSITIVITY OF MATERIALS IN CONTACT WITH LIQUID OXYGEN PAGES 6-10//TABLE 2 EFFECT OF IMPACT ENERGY ON SENSITIVITY PAGE 11//TABLE 3 EFFECT OF IMPACT ENERGY ON SENSITIVITY PAGE 12 //TABLE 4 IMPACT SENSITIVITY OF MATERIALS IN CONTACT WITH LIQUID OXYGEN PAGE 12(A)

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LIQUID OXYGEN DISPOSAL VESSEL EXPLOSION

by

BOYNE, W.J.

00/00/66

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-ABSTRACT-

AN EXPLOSION OCCURRED IN THE LIQUID OXYGEN DISPOSAL VESSEL OF AN AIR SEPARATION PLANT THAT WAS DESIGNED AND OPERATED IN SUCH A WAY AS TO AVOID ANY HAZARDOUS HYDROCARBON CONCENTRATIONS. A BLEED OF LIQUID OXYGEN FROM THE REBOILER PREVENTS A BUILD-UP OF IMPURITY CONCENTRATIONS IN THE LIQUIFIER. THE TRANSFER OF IMPURITIES FROM A HYDROCARBON CONTAMINATED GASEOUS NITROGEN STREAM, EXISTING FROM A RICH LIQUID FILTER UNDERGOING REGENERATION, TO LIQUID PHASE PURGE OXYGEN WHILE THEY FLOWED CONCURRENTLY THROUGH THE PURGE PIPING TO THE DISPOSAL TANK SUBSTANTIALLY INCREASED TO A HYDROCARBON LEVEL IN THE LIQUID TO A HAZARDOUS CONDITION WHICH THEN WAS PRESUMABLY IGNITED AND DETONATED BY A STEAM HEATED VAPORIZATION TRAY IN THE DISPOSAL UNIT. MODIFICATIONS PREVENT THE REGENERATION GAS FROM INTIMATELY CONTACTING THE PURGE LIQUID OXYGEN, THEREBY INHIBITING ANY TRANSFER AND BUILDUP OF CONTAMINANTS IN THE PURGE STREAM.

-PERTINENT FIGURES-

FIG.1 SIMPLIFIED PROCESS FLOW DIAGRAM, PAGE 7//FIG.2 ENGINEERING SKETCH OF THE LIQUID OXYGEN DISPOSAL VESSEL, PAGE 8//FIG.6 TYPICAL CONCENTRATION PROFILE FOR ACETYLENE, PAGE 10//TAB.1 HYDROCARBON ANALYSIS FOR PURGE LIQUID OXYGEN, PAGE 10

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THE RELATIONSHIP OF PHYSICAL, CHEMICAL AND THERMODYNAMIC
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MCKINLEY, C.

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-ABSTRACT-

SEVERAL TESTS WERE CONDUCTED TO OBTAIN EXPERIMENTAL DATA ON THE EXPLOSIVE AND DETONATION CHARACTERISTICS OF HYDROCARBON - LIQUID OXYGEN MIXTURES. A LIQUID MIXTURE OF 25 MOLE PERCENT METHANE AND 75 MOLE PERCENT OXYGEN AT 76 K WAS DETONATED WITH A DYNAMITE CAP TO DETERMINE IF AN EXPLOSION COULD RESULT FROM CONDENSATION AND FRACTIONIZATION OF HYDROCARBONS AND AIR ON THE OUTSIDE OF A COLD PIPE. ANOTHER TEST WAS CONDUCTED TO DETERMINE THE LOWER EXPLOSIVE LIMITS OF A 50 - 50 METHANE - ETHANE MIXTURE IN LIQUID OXYGEN. IT WAS DETERMINED THAT THE LOWER EXPLOSIVE LIMIT FOR THE MIXTURE WAS ABOUT 6.2 MOLE PERCENT. THE POSSIBILITY OF A RELATIONSHIP BETWEEN THE EXPLOSIVE LIMITS OF GAS PHASE AND LIQUID PHASE CH(4)-O(2) MIXTURES WAS DISCUSSED. AN EXPERIMENTAL TEST WAS CONDUCTED TO DETERMINE THE LOWER AND UPPER EXPLOSION LIMITS OF METHANE IN LIQUID OXYGEN AT -320 DEGREES F, AND THE TEST RESULTS INDICATED THAT THESE LIMITS ARE 10.5 AND 59 MOLE PERCENT METHANE IN LIQUID OXYGEN. A TEST WAS CONDUCTED TO DETERMINE IF CONCENTRATED HYDROCARBON CONTAMINATION IN SILICA GEL ADSORBENT COULD DETONATE IN LIQUID OXYGEN. MIXTURES OF 4 AND 5 MOLE PERCENT ETHANE IN LIQUID OXYGEN WERE DETONATED AT -320 DEGREES F. VARIOUS ASPECTS OF THE EXPERIMENTAL TESTS WERE DISCUSSED.

-PERTINENT FIGURES-

TAB.1 GAS PHASE FLAMMABLE LIMITS - CARBON ATOM APPROXIMATION PAGE
81

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SAFETY ASPECTS OF RECONSTRUCTED ICI TONNAGE OXYGEN PLANT

by

MATTHEWS, W.D.
OWEN, S.G.

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-ABSTRACT-

ON 21ST APRIL, 1959, A SERIOUS EXPLOSION OCCURRED IN THE TONNAGE OXYGEN PLANT AT THE WORKS OF IMPERIAL CHEMICAL INDUSTRIES LIMITED AT BILLINGHAM-ON-TEES, ENGLAND, DURING THE COMMISSIONING PROCEDURES. THE EXPLOSION CAUSED THREE DEATHS, AND EXTENSIVE DAMAGE BOTH TO THE PLANT AND TO NEARBY FACILITIES. A COMPREHENSIVE AND DETAILED INVESTIGATION WAS UNDERTAKEN JOINTLY BY AIR PRODUCTS LTD. AND ICI, AND EXPERT ASSISTANCE WAS ALSO PROVIDED FROM INDEPENDENT SOURCES. WHILE THE INVESTIGATION CONCLUDED THAT THE CONSTITUENTS OF THE EXPLOSIVE MATERIAL WERE HYDROCARBON OIL FROM THE LUBRICATING SYSTEM OF THE TURBO EXPANDERS AND LIQUID OXYGEN FROM LEAKING PIPE JOINTS IN THE COLD BOX, A CRITICAL REAPPRAISAL (IN THE LIGHT OF THE GROWING KNOWLEDGE OF THE HAZARDS ASSOCIATED WITH AIR SEPARATION PLANTS) OF ALL ASPECTS OF PROCESS AND ENGINEERING DESIGN, FABRICATION AND ERECTION, WHICH COULD BE REGARDED IN ANY WAY AS BEING POTENTIALLY HAZARDOUS, WAS UNDERTAKEN BY ICI AND APL PRIOR TO AND DURING THE RECONSTRUCTION OF THE PLANT. AT THE SAME TIME, AIR PRODUCTS LTD. INTRODUCED CERTAIN IMPROVEMENTS RELATING TO THE CYCLE, THIS PAPER, HOWEVER, IS CONFINED TO CONSIDERATION ONLY OF THOSE CHANGES WHICH WERE RELEVANT TO SAFETY.

-PERTINENT FIGURES-

FIG. 9 FINAL DESIGN OF LOX JOINT, PAGE 9//FIG. 10 STRESS VARIATION IN LOX FLANGE BOLTS DURING COOLING CYCLES, PAGE 9

-SOURCE INFORMATION-

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THE ROLE OF AIR CONTAMINANTS IN FORMULATING OXYGEN PLANT SAFETY PRINCIPLES

by

MCKINLEY, C.
HIMMELBERGER, F.

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-ABSTRACT-

THIS ARTICLE TRACES THE HISTORY OF THE DEVELOPMENT OF AIR SEPARATION PLANTS RELATIVE TO SAFETY FROM EXPLOSIONS DUE TO CONTAMINANTS THAT REACT WITH OXYGEN. A TABLE OF ABOUT 25 COMMON CONTAMINANTS IN AN AIR PLANT SHOWS THE NORMAL BOILING AND FREEZING POINTS. ANOTHER TABLE SHOWING THE SOLUBILITY LIMITS OF MOST OF THESE CONTAMINANTS IS ALSO GIVEN. THE EXPLOSION CHARACTERISTICS AND FLAMMABILITY LIMITS OF SEVERAL OF THE CONTAMINANTS IN LIQUID OXYGEN ARE DISCUSSED. METHODS OF CONTAMINATION LEVEL CONTROL OR REMOVAL ARE MENTIONED. ALSO DISCUSSED ARE METHODS OF PREVENTING EXPLOSIONS. EXPERIMENTAL EXPLOSION TEST DATA IS GIVEN. CONTINUOUS HYDROCARBON ANALYSIS IS RECOMMENDED.

-PERTINENT FIGURES-

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INVESTIGATION OF REACTIVITY OF LAUNCH VEHICLE MATERIALS
WITH LIQUID OXYGEN. FINAL REPORT, 22 APR. 1968 - 18 APR.
1969.

by

MILL, T.
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-ABSTRACT-

THE IMPACT SENSITIVITY OF ORGANIC COMPOUNDS IN LIQUID OXYGEN WAS STUDIED TO DEFINE THE IGNITION MECHANISM IN LOX AND TO ESTABLISH THE RELATIONSHIP BETWEEN SENSITIVITY AND CHEMICAL AND PHYSICAL PROPERTIES. A MODIFIED ARMA DROP-WEIGHT TESTER WAS USED TO MEASURE THE IMPACT SENSITIVITY. FOR 18 OF THE 24 COMPOUNDS TESTED, A POSITIVE CORRELATION WAS FOUND TO EXIST BETWEEN THE RELATIVE SENSITIVITY AND FLASH POINT. FIVE OTHER COMPOUNDS, REACTIVITY IN OXIDATION. THE RELATIVE REACTIVITY OF T-BUTOXY AND T-BUTYL OXY RADICALS TOWARD A VARIETY OF ORGANIC COMPOUNDS AT 50 DEGREES AND 100 DEGREES C WAS EXAMINED. A GOOD CORRELATION WAS FOUND BETWEEN RELATIVE REACTIVITY OF BOTH RADICALS TOWARD FIVE DROCARBONS. THE CORRELATION FOR FOUR ALIPHATIC DERIVATIVES WAS ALSO GOOD. NO CORRELATION WAS FOUND BETWEEN REACTIVITY IN OXIDATION AND IMPACT SENSITIVITY FOR THE ALIPHATIC COMPOUNDS TESTED.

-PERTINENT FIGURES-

FIG. 1 HOT-WIRE IGNITION APPARATUS PAGE 14//FIG. 2 HOT-WIRE APPARATUS SCHEMATIC DIAGRAM PAGE 15//FIG. 3 SAMPLE SUPPORT APPARATUS PAGE 17//FIG. 4A NON-IGNITION (BLANK) PAGE 20//FIG. 4B IGNITION OF BENZYL ALCOHOL (NO. 1) PAGE 20//FIG. 4C IGNITION OF BENZYL ALCOHOL (NO. 2) PAGE 20//FIG. 5 PLATINUM WIRE VS BRIDGE OUTPUT PAGE 21//FIG. 6 DROP-WEIGHT TESTER MODIFIED FOR HIGH-SPEED PHOTOGRAPHY PAGE 24//FIG. 7 CROSS SECTION OF ANVIL ASSEMBLY PAGE 26//FIG. 8 LEXAN ANVIL-CUP PAGE 27//FIG. 9 STILL PHOTOGRAPH OF ACTION FLASH PAGE 28//FIG. 10 TRIGGERED TRACES OF REACTION FLASH PAGE 30//FIG. 10A IMPACT TRIGGERED TRACE PAGE 30//FIG. 10B LIGHT TRIGGERED TRACE PAGE 30//FIG. 11 IMPACT IGNITION AND PROPAGATION OF BENZYL ALCOHOL IN LIQUID OXYGEN PAGE 32//FIG. 12 APPARATUS FOR LOW-TEMPERATURE OXIDATION OF ME(6)AL(2) PAGE 49//FIG. 13 NMR SPECTRA OF REACTIONS OF ME(6)AL(2) WITH O(2) OF MEOH AT LOW TEMPERATURE PAGE 52//TAB. I IMPACT SENSITIVITY VS PHYSICAL

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 //TAB.IV COMPARISON OF IMPACT AND HOT-WIRE SENSITIVITY DATA PAGE
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 IN BENZENE PAGE 42//TAB.IX REACTION OF OXYGEN WITH ME(6)AL(2) IN
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REACTION PROCESSES IN HIGH-PRESSURE FLUID SYSTEMS FINAL
REPORT PANEL 7

by

DOWNS, W.R.

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-ABSTRACT-

THIS REPORT PRESENTS THE RESULTS OF THE PHYSICAL, METALLURGICAL, CHEMICAL, AND THERMODYNAMIC SURVEYS THAT HAVE BEEN MADE ON THE HIGH-PRESSURE TANK AND PLUMBING SYSTEMS OF THE APOLLO SPACECRAFT. THESE SYSTEMS COMPRISE THE PRESSURIZED OXYGEN, HYDROGEN, NITROGEN, PROPELLANT, AND HELIUM TANKS AND RELATED PLUMBING OF THE COMMAND, SERVICE, AND LUNAR MODULES. THE PURPOSES OF THE SURVEYS ARE TO LEND SUPPORT TO THE APOLLO 13 INVESTIGATION, TO PROVIDE REVIEW AND TO EXTEND KNOWLEDGE OF SPACECRAFT PRESSURE SYSTEMS, AND TO CONTRIBUTE TO THE SAFETY OF FUTURE MANNED SPACE FLIGHTS. TO ACHIEVE THESE OBJECTIVES, DESCRIPTIVE DATA FOR ALL TANKS WERE COLLECTED, A METALLURGICAL SURVEY AND A COMPREHENSIVE PHYSICAL CHEMICAL SURVEY OF ALL SYSTEMS WERE MADE, AND SOME DETAILED THERMODYNAMICAL CALCULATIONS WERE PERFORMED. THE OVERALL DESCRIPTIVE SURVEY OF THE HIGH-PRESSURE TANKS USED ON THE APOLLO SPACECRAFT SYSTEMS, INCLUDING A REVIEW OF THE METALLURGY INVOLVED IN THEIR CONSTRUCTION, POINTED TO (1) THE IMPORTANCE OF A CRITICAL EXAMINATION OF ANY INCOMPATIBILITIES IN MATERIALS SELECTIONS AND (2) THE NEED FOR PHYSICAL CHEMISTRY AND CATALYSIS STUDIES OF THE REACTION PROCESSES INVOLVED IN HIGH-PRESSURE FLUID SYSTEMS. THE RESULT IS A CRITICAL ASSESSMENT OF THE PHYSICAL AND CHEMICAL PROCESSES THAT CAN OCCUR IN HIGH-PRESSURE FLUIDS AND AN ASSESSMENT OF THE HAZARDS AND POSSIBLE FAILURE MECHANISMS ASSOCIATED WITH CONTAINMENT OF CRYOGENIC MATERIALS. FINDINGS BASED ON THESE SURVEYS ARE TABULATED IN THE REPORT. THE REPORT IS EXCELLENT.

-PERTINENT FIGURES-

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INVESTIGATION OF REACTIVITY OF LAUNCH VEHICLE MATERIALS
WITH LIQUID OXYGEN QUARTERLY REPT. NO. 2, JUL 23 - OCT 22,
1968

by

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11/12/68

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-ABSTRACT-

THIS PROGRAM HAS TWO MAJOR ASPECTS. (A) STUDY OF THOSE FACTORS AFFECTING THE IGNITION PROCESSES AND (B) STUDY OF THE CHEMICAL MECHANISMS OF FREE RADICAL FORMATION AND OXIDATION OF SELECTED ORGANIC MATERIALS. DURING THIS QUARTER, MOST OF THE EFFORT ON THE FIRST ASPECT OF THE PROGRAM WAS DEVOTED TO MEASUREMENTS OF IMPACT SENSITIVITY OF SEVERAL HOMOLOGOUS SERIES OF ORGANIC COMPOUNDS INCLUDING AROMATICS, NORMAL AND CYCLOALKANES, AND ISOPROPYL DERIVATIVES. SOME CORRELATIONS BETWEEN IMPACT SENSITIVITY AND PHYSICAL PROPERTIES HAVE BEEN NOTED. CALIBRATION OF THE HOT-WIRE APPARATUS HAS BEEN COMPLETED. IN THE SECOND PART OF THE PROGRAM, WORK HAS CONTINUED ON THE REACTION OF OXYGEN WITH TRIMETHYLALUMINUM AT -140 DEGREES. KINETIC DATA INDICATE THE REACTION IS BIMOLECULAR AND EXCEPTIONALLY FAST. REACTIONS OF T-BUTOXY RADICAL WITH BENZYL AND ISOPROPYL COMPOUNDS REVEALED SOME SURPRISING REACTIVITY RELATIONSHIPS. BUT NO CLEAR EVIDENCE WAS OBTAINED FOR CORRELATIONS WITH IMPACT SENSITIVITY MEASUREMENTS.

-PERTINENT FIGURES-

FIG.1 SAMPLE SUPPORT APPARATUS, PAGE 9//FIG.2 BRIDGE OUTPUT VERSUS PLATINUM WIRE TEMPERATURE, PAGE 12//FIG.3 HOT WIRE IGNITION OF BENZYL ALCOHOL, PAGE 14//TAB.1 INITIAL SCREENING TESTS FOR PURE ORGANIC COMPOUNDS, PAGE 5//TAB.2 IMPACT TESTS OF FOUR PURE ORGANIC COMPOUNDS, PAGE 7//TAB.3 FIXED TEMPERATURES FOR HOT-WIRE CALIBRATION, PAGE 11

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3. E., RUMPEL, W. F. MECHANICALLY INITIATED REACTIONS OF ORGANIC MATERIALS IN MISSILE OXIDIZERS. THE MARTIN CO. AERONAUTICAL SYSTEMS DIVISION, ASD TECHNICAL REPORT 61-324, OCTOBER, 1961, AD 268458//P. P. BOWDEN AND A. D. YOPPE, INITIATION AND GROWTH OF EXPLOSIVES IN LIQUIDS AND SOLIDS, CAMBRIDGE UNIVERSITY PRESS, 1952//CALCULATED FROM DATA OF A. W. LAUBENGAYER AND W. P. GILLIAN, J. AMER. CHEM. SOC., 63, 477 (1944)//K. RAMEY, ET AL., J. PHYS. CHEM., 69, 3413 (1965)//C. WALLING AND P. J. WAGNER, J. PHYS. CHEM., 86, 3368 (1964)

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OXYGEN PLANT SAFETY

by

KARWAT, E.

04/00/57

SECURITY CLASS	ACCESS LEVEL	REPORT CLASS	ENTRY EVAL.
J/Unrestricted	Unlimited	Summary	Acceptable

-ABSTRACT-

THIS SHORT ARTICLE DISCUSSES THE RELATIVE SAFETY AND YET OCCASIONAL EXPLOSIONS THAT OCCUR IN LIQUID OXYGEN GENERATING PLANTS. EXPERIMENTS WITH ACETYLENE SHOW THE LONGER AS WELL AS SAFE OPERATING LIMITS FOR THIS MATERIAL OZONE IS ALSO DISCUSSED AND EXPLOSIVE LIMITS GIVEN (ROUGHLY 18 PERCENT BY VOLUME IN LIQUID OXYGEN)) FOR LOX CONTAINING HYDROCARBON IMPURITIES, GREAT CARE MUST BE TAKEN IN VAPORIZING THE LIQUID.

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CORPORATE SOURCE -

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JOURNAL PROCEEDINGS -

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OXYGEN PLANT VAPORIZER EXPLOSION

by

WRIGHT, G. I.

04/00/61

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ENTRY EVAL.
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-ABSTRACT-

AN EXPLOSION OCCURRED IN THE VAPORIZER OF A LIQUID AIR SEPARATION PLANT AT THE DOMINION FOUNDRIES AND STEEL, LTD, HAMILTON, ONTARIO, SEPT. 30, 1959. THE AUTHOR DESCRIBES THE AIR LIQUEFICATION, PURIFICATION AND SEPARATION CYCLE BRIEFLY AND THEN SPECULATES ON THE CAUSE OF THE EXPLOSION. AN EXCESSIVE ACCUMULATION OF ACETYLENE IN THE VAPORIZER DUE TO EXCESSIVE WARMING OF THE REGENERATOR IS BELIEVED TO HAVE CAUSED THE EXPLOSION. THE SOURCE OF THE CONTAMINANT MOST LIKELY CAME FROM NEARBY COKE OVENS. LARGE VOLUMES OF CO(2) WERE ALSO PRESENT. THE DAMAGE TO THE PLANT IS ILLUSTRATED AND DESCRIBED BRIEFLY. MANY CORRECTIVE MEASURES WERE MADE TO THE PLANTS AND IN THE OPERATING PROCEDURES. SAFETY ALARMS AND PURIFICATION TESTS WERE ADDED. THE PAPER IS PRIMARILY CONCERNED WITH SAFETY.

-PERTINENT FIGURES-

TAB.1 ACETYLENE CONTAMINANT LEVELS IN PLANT OPERATION, PAGE 11//TAB.2 CONTAMINANTS ON THE RICH-LIQUID AND LIQUID OXYGEN FILTERS IN NO. 2 AND NO. 3 PLANTS, PAGE 11

-SOURCE INFORMATION-

CORPORATE SOURCE -

DOMINION FOUNDRIES AND STEEL LTD., CANADA

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DISCUSSION OF ENERGY RELEASE IN A LIQUID OXYGEN PUMP

by

FALL, W.L.

00/00/63

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Unlimited

REPORT CLASS
Summary

ENTRY EVAL.
Acceptable

-ABSTRACT-

THIS REPORT DISCUSSES A LIQUID OXYGEN PUMP INCIDENT THAT RESULTED IN CONSIDERABLE DAMAGE TO THE PUMP AND SHUTDOWN OF AN AIR SEPARATION PLANT. THE PUMP DESCRIBED IS A 10-STAGE VERTICAL PUMP WHICH TAKES LIQUID OXYGEN FROM THE REBOILER OVERFLOW AND DISCHARGES TO THE MAIN AIR EXCHANGERS WHERE THE LIQUID IS VAPORIZED AND SENT TO STORAGE OR TRANSMISSION LINES. FOR RELIABILITY, TWO PUMPS ARE INSTALLED (ONE AS A SPARE) IN A SINGLE INSULATED PUMP BOX, AND THE SPARE PUMP IS KEPT ON COLD STAND-BY. INVESTIGATION REVEALED THAT THE COLD STAND-BY PROCEDURE PROVIDED MEANS OF CONCENTRATING CONTAMINANTS IN THE PUMP, AND ALTERNATE NON-CONCENTRATING METHODS OF COOLING WERE STUDIED AS A RESULT.

-SOURCE INFORMATION-

CORPORATE SOURCE -

AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA.

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EXPLOSIONS CAUSED BY LIQUID OXYGEN

by

WEPER, U.

00/00/63

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Summary

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-ABSTRACT-

CHEMISTS HAVE KNOWN FOR A LONG TIME THAT ALTHOUGH LIQUID OXYGEN ITSELF IS NON-FLAMMABLE AND NON-TOXIC, ITS HANDLING NEVERTHELESS PRESENTS SERIOUS RISKS AS ALL COMBUSTION IN THE PRESENCE OF OXYGEN IS MUCH QUICKER THAN IN THE AIR AND BECAUSE MIXTURES OF ORGANIC SUBSTANCES WITH LIQUID OXYGEN CAN EXPLODE. HANDLING OF OXYGEN IN LABORATORIES THEREFORE IS CARRIED OUT WITH EVERY RECOGNISED PRECAUTION AND ACCIDENTS ARE RARE. UNFORTUNATELY, IN RECENT TIMES, SOME SERIOUS EXPLOSIONS HAVE OCCURRED IN THE FEDERAL REPUBLIC OF GERMANY IN INDUSTRIES USING LIQUID OXYGEN ON A LARGE SCALE AND AT THE TIME OF TRANSPORTING THE LIQUID OXYGEN BY TANKER. THESE ACCIDENTS HAVE LED THE AUTHORITIES TO TAKE CERTAIN SPECIAL SAFETY MEASURES WHICH MAY BE OF INTEREST TO OTHERS CONCERNED WITH THIS BRANCH OF ACTIVITY. THE EXAMPLES AND SAFETY MEASURES CITED IN THIS ARTICLE ARE OF GENERALLY COMMON KNOWLEDGE TODAY, HOWEVER, AND IT IS THEREFORE OF MARGINAL INTEREST.

-SOURCE INFORMATION-

JOURNAL PROCEEDINGS -

CHIM. IND. VOL 90, NO. 3, 178-83 (1963) (TRANSLATED BY ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL, BERKSHIRE)

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SAFETY ASPECTS IN THE DESIGN AND OPERATION OF OXYGEN
SYSTEMS

by

REYNALES, C.H.

01/00/59

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REPORT CLASS
Summary

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-ABSTRACT-

THIS PAPER DEALS WITH THE BEHAVIOR AND PROPERTIES OF OXYGEN AS THEY APPLY TO SAFETY ASPECTS IN THE DESIGN AND OPERATION OF THE OXYGEN TRANSFER SYSTEM OF THE THOR MISSILE. THE PAPER SUMMARIZES THE FINDINGS OF A STUDY ON THE COMPATIBILITY OF MATERIALS WITH OXYGEN, LISTS THE RESULTS OF VARIOUS TESTS PERFORMED TO DETERMINE THE RESISTANCE OF MATERIALS AND CONTAMINANTS TO IGNITION IN AN OXYGEN ATMOSPHERE, AND REVIEWS THE OBSERVATIONS FROM A FIELD SURVEY MADE AMONG THE ORGANIZATIONS MOST ACTIVELY ENGAGED IN THE PRODUCTION AND USE OF OXYGEN. THE OVERALL CONCLUSION FROM THIS PROJECT IS THAT OXYGEN IS A POTENTIAL EXPLOSIVE WHICH SHOULD BE HANDLED WITH CARE. THERE ARE THREE BASIC ELEMENTS REQUIRED FOR COMBUSTION, ONE OF WHICH IS OXYGEN. THE OTHER TWO ARE THE COMBUSTIBLE MATERIALS AND THE SOURCES OF ENERGY NEEDED TO INDUCE A REACTION. UNTIL WE LEARN MORE ABOUT THE FIRST ELEMENT, OXYGEN, IT IS NECESSARY TO CONTROL THE OTHER TWO. THIS CAN BE DONE BY REDUCING OR ELIMINATING THE SOURCES OF ENERGY THROUGHOUT A SYSTEM AND BY A CLEANING AND MAINTENANCE PROGRAM AIMED AT THE ELIMINATION AND AVOIDANCE OF CONTAMINANTS.

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JOURNAL PROCEEDINGS -
CHEMICAL CLEANING OF MISSILE LAUNCHING FACILITIES AND
COMPONENTS SYMP., TULSA, OKLA., JAN 20-1, 1959. PAPER NO. 741
OTHER INFORMATION -
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SURVEY OF ACCIDENTS AT THE AIR SEPARATION PLANTS

-ABSTRACT-

A LARGE NUMBER OF ACCIDENTS WHICH OCCURRED IN AIR SEPARATION PLANTS IN JAPAN AND ELSEWHERE ARE ANALYZED. CLAUDE-TYPE, LINDE-TYPE, AND FRANKEL-TYPE SEPARATION PLANTS ARE DISCUSSED. ACCIDENTS WERE CLASSIFIED INTO EXPLOSIONS, BURSTING ACCIDENTS AND ACCIDENTS IN WHICH HUMANS WERE INJURED OR KILLED. VARIOUS ACCIDENT MODES ARE ANALYZED, AND THE SUCCESS OF APPROPRIATE COUNTERMEASURES IS DESCRIBED. DATA ON ALL AIR SEPARATION PLANTS IN JAPAN ARE GIVEN. MANY SAFETY RECOMMENDATIONS ARE GIVEN THROUGHOUT THE REPORT.

-PERTINENT FIGURES-

TAB. 1 CLASSIFICATION OF ACCIDENTS BY THE TYPE, PAGE 13//TAB. 2 CLASSIFICATION OF ACCIDENTS BY THE LOCATION, PAGE 14//TAB. 3 CLASSIFICATION BY INDUSTRY, PAGE 14//TAB. 4 YEARLY BREAKDOWN BY THE NUMBER OF ACCIDENTS, PAGE 15//TAB. 5 MONTHLY CLASSIFICATION, PAGE 16//TAB. 6 RELATIONS BETWEEN THE TYPE AND THE LOCATION OF THE ACCIDENTS, PAGE 16//TAB. 7 RELATION BETWEEN THE INDUSTRY AND THE TYPE OF ACCIDENT, PAGE 16//TAB. 8 EXPLOSION ACCIDENTS IN THE AIR SEPARATION PLANT, PAGES 18-36//TAB. 9 BURSTING ACCIDENTS IN THE AIR SEPARATION PLANT, PAGES 44-47//TAB. 10 HUMAN ACCIDENT (BURN, FROST-BITE, SUFFOCATION) IN THE AIR SEPARATION PLANT, PAGES 48-51//TAB. 11 THE ACCIDENTS IN FOREIGN COUNTRIES, PAGES 52-55//TAB. 12 PROPERTIES OF SOME OF THE AIR POLLUTANTS, PAGE 56//TAB. 13 SOLUBILITIES OF VARIOUS SUBSTANCES IN LIQUID OXYGEN AT MINUS 196 DEGREES C, PAGE 58//TAB. 14 EXPLOSION LIMITS OF VAPORS, PAGE 60//TAB. 15 EXPLOSION AND DETONATION LIMITS - GAS PHASE, PAGE 61//FIG. 9 SOLUBILITY OF ACETYLENE IN LIQUID

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keys 8205 through 8206

INVESTIGATION OF REACTIVITY OF LAUNCH VEHICLE MATERIALS
WITH LIQUID OXYGEN, QUARTERLY REPORT NO. 3/ OCT 23, 1968 TO
JAN 22, 1969

by

MILL, T.
CHAMBERLAIN, D.L.
STRINGHAM, R.S.
KIRSHEN, N.A.
IRWIN, K.C.

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-ABSTRACT-

A SELECTED GROUP OF ORGANIC COMPOUNDS WERE IMPACT TESTED WITH THE ABMA DROP-WEIGHT TESTER DURING THIS REPORT PERIOD. ATTEMPTS WERE MADE TO CORRELATE THE IMPACT SENSITIVITIES OF THESE COMPOUNDS WITH THEIR PHYSICAL PROPERTIES AND CHEMICAL STRUCTURE. IN SOME INSTANCES SUBGROUPS OF COMPOUNDS THAT ARE RELATED BY THEIR CHEMICAL STRUCTURE HAVE EXHIBITED SENSITIVITIES CORRELATING WITH THEIR FLASH POINTS. CHEMICAL STRUCTURE HAS ALSO BEEN SHOWN TO BE A FACTOR IN IMPACT SENSITIVITY. THE IMPACT SENSITIVITIES OF CUMENE, TOLUENE, AND T-BUTYLBENZENE ARE IN THE SAME ORDER AS THEIR REACTIVITIES TOWARD PEROXY RADICALS IN OXIDATION. A FEW OF THE COMPOUNDS THAT WERE IMPACT TESTED WERE IGNITED BY THE HOT-WIRE METHOD, AND MINIMUM IGNITION TEMPERATURES AND IGNITION-DELAY TIMES WERE MEASURED. THE HOT-WIRE SENSITIVITY OF COMPOUNDS WITHIN CERTAIN SUBGROUPS WERE AGAIN FOUND TO CORRELATE WITH THE EASE OF HOT-WIRE IGNITION. FURTHERMORE, HOT-WIRE DATA APPEAR TO AGREE WITH IMPACT DATA. TWO PRELIMINARY EXPERIMENTS LEADING TO THE USE OF HIGH-SPEED PHOTOGRAPHY FOR THE STUDY OF IMPACT-INDUCED IGNITION MECHANISMS WERE PERFORMED.

-PERTINENT FIGURES-

TAB.1 IMPACT SENSITIVITY VERSUS PHYSICAL PROPERTIES FOR PURE ORGANIC COMPOUNDS, PAGE 6//TAB.2 COMPARISON OF IMPACT AND HOT-WIRE SENSITIVITY DATA, PAGE 9//TAB.3 REACTION OF OXYGEN WITH Me(6)Al(2) IN CF_2Cl_2 , PAGE 18

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PROPELLANT STATIC SEAL DEVELOPMENT IN PROJECT HERMES

by

JENKINS, T.C.
LOGAN, S.E.

11/00/54

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U/Unrestricted	NTIS	Summary	Acceptable

-ABSTRACT-

THIS REPORT REVIEWS THE ADVANCEMENTS MADE TOWARD BETTER PROPELLANT SEALING DEVICES DURING THE HERMES PROGRAM. IT DISCUSSES THE PROBLEMS WHICH WERE OVERCOME IN THE DESIGN OF COMPONENTS CARRYING LIQUID OXYGEN. IMPROVEMENTS ARE NOTED FOR TUBE JOINTS, AND DETONATION TESTS WITH VARIOUS ELASTOMERS ARE DISCUSSED.

-PERMANENT FIGURES-

FIG. 41 DETONATION TEST SCORE VERSUS FILLER FOR VARIOUS ELASTOMERS, PAGE 36// FIG. 42 DETONATION TEST SCORE VERSUS HARDNESS FOR VARIOUS ELASTOMERS, PAGE

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CORPORATE SOURCE -
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SAFETY PRECAUTIONS WITH RESPECT TO HYDROCARBONS IN AIR
FRACTIONATING APPARATUS (SCHUTZMAßNAHMEN GEGEN
KOHLENWASSERSTOFFE IM LUFTTRENNER)

by

KARWAT, E.

11/00/60

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REPORT CLASS
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ENTRY EVAL.
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-ABSTRACT-

THIS REPORTS THE INVESTIGATION OF AN EXPLOSION IN THE LINDE-FRAENKL APPARATUS IN AN AIR SEPARATION PLANT. THE EXPLOSION TOOK PLACE WHEN LIQUID OXYGEN FROM THE ACETYLENE SEPARATOR WAS DISCHARGED. PREVIOUS TESTS SHOWED THAT THE ACETYLENE CONTENT OF THE STREAM WAS LESS THAN 0.01 PPM SO THAT THE EXPLOSION MUST HAVE BEEN CAUSED BY OTHER HYDROCARBONS. IT APPEARS THAT THE PROPYLENE PRESENT IN THE STREAM PREVENTS THE SORPTION OF ETHANE AND IMPAIRS THE SORPTION OF PROPANE AND ETHYLENE. THE AUTHOR RECOMMENDS - 1) MORE VIGOROUS FLUSHING OF THE AUXILIARY VAPORIZER, WITH THE RETURN OF THE OVERFLOW LIQUID THROUGH THE ADSORBER PLACED AHEAD OF THE AUXILIARY VAPORIZER. 2) SCRUBBING OUT OF THE HYDROCARBONS FROM THE AIR WITH THE SMALLEST POSSIBLE AMOUNT OF LIQUID AIR BEFORE ITS ENTRANCE INTO THE COLUMN. 3) ADSORPTION OF THE HYDROCARBONS FROM THE GASEOUS AIR BETWEEN THE REGENERATOR AND THE COLUMN. 4) REGENERATIVE ADSORPTION/DESORPTION OF THE AIR ON A SORBENT LAYER PLACED AT THE COLD END OF THE REGENERATOR. 5) BURNING OF THE HYDROCARBONS BEFORE THE AIR ENTERS THE FRACTIONATOR. THE PAPER INCLUDES DETAILS FOR IMPLEMENTING THE RECOMMENDATIONS.

-PERTINENT FIGURES-

FIG. 1 ADSORPTION OF VARIOUS HYDROCARBONS ON SILICA GEL FROM THEIR SOLUTION IN LIQUID OXYGEN, PAGE 13//FIG. 2 FLUCTUATIONS IN THE PROPANE CONTENT OF THE LIQUID IN THE PRESSURE COLUMN AND IN THE MAIN CONDENSER, PAGE 14//FIG. 3 ADSORBER FOR THE OVERFLOW LIQUID FROM THE AUXILIARY VAPORIZER, PAGE 15//FIG. 4 TEMPERATURE CHANGES IN THE GEL LAYER REGENERATOR, PAGE 16

-SOURCE INFORMATION-

CORPORATE SOURCE -

PULLACH NEAR MUNICH

JOURNAL PROCEEDINGS -

LINDE BER. TECH. WISS., NO. 10, 12-6 (NOV 1960) (IN GERMAN)
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-ABSTRACT-

SUBJECTS DISCUSSED IN THE SYMPOSIUM INCLUDED SAFE DESIGN AND SAFE OPERATING PROCEDURES IN AIR SEPARATION PLANTS, A HYDROCARBON CONTAMINATION INCIDENT AND SAFE PURGING PROCEDURES DEVELOPED FOR SUCH INCIDENTS, AND EXPLOSIONS IN AN AIR SEPARATION PLANT AND IN A COMPRESSOR, BOTH CAUSED BY CONTAMINATION. THE PAPERS INDEXED FOR ASDI ARE//HUGILL, J. T., YOUNG, V. M., ANDERSON, C. P., SIMMS, R. K., COCHRANE, G. S., ET AL, REBOILERS AND VAPORIZERS//ANDERSEN, C. P., UNATTENDED OXYGEN PLANTS// BOLLEN, R. F., HYDROCARBON CONTAMINATION OF AN AIR SEPARATION PLANT// GIBBS, C. W., COMPRESSOR EXPLOSION//ROTZLER, R. W., GLASS, J. A., GORDON, W. E., HESLOP, W. R., OXYGEN PLANT REBOILER EXPLOSION.

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AVIATORS BREATHING OXYGEN FROM AIRCRAFT CONVERTERS,
EVALUATION OF

-ABSTRACT-

TWO SAMPLES OF AVIATORS BREATHING OXYGEN WERE ANALYZED FOLLOWING AN ACCIDENT IN WHICH A PILOT WAS KILLED. THE LIQUID OXYGEN HAD BEEN OBTAINED FROM THE AIRCRAFT CARRIER USS BENNINGTON. THE SAMPLES WERE TAKEN FROM LCX CONVERTERS OF AIRCRAFT WHICH HAD OBTAINED LOX FROM THE BENNINGTON AT THE SAME TIME AS THE AIRCRAFT INVOLVED IN THE FATAL CRASH. THE SAMPLES CONTAINED CONTAMINANTS FAR IN EXCESS OF THE MAXIMUMS ALLOWED UNDER SPECIFICATIONS. PILOT COMPLAINTS OF BAD ODORS, HEADACHES, NAUSEA, AND LOSS OF COORDINATION WERE ATTRIBUTED TO THE OXYGEN SUPPLY. IT IS SUGGESTED THAT THE TOXIC EFFECTS OF THE CONTAMINANTS MIGHT BE ENHANCED WHEN BREATHING PURE OXYGEN. IN ADDITION, ONE SAMPLE CONTAINED ACETYLENE IN EXCESS OF ITS SOLUBILITY IN LOX, CONSTITUTING AN EXPLOSIVE HAZARD. THE REPORT RECOMMENDS THAT MEANS OF MONITORING CONTAMINANT LEVELS IN LOX BE PROVIDED TO AIRCRAFT CARRIERS AND ALL LAND-BASED PLANTS WHICH DO NOT HAVE SUCH INSTRUMENTATION. A SUGGESTED INSTRUMENT IS A GAS CHROMATOGRAPH SUCH AS THE NRL TOTAL HYDROCARBON ANALYZER.

-PERTINENT FIGURES-

TAB. ANALYTICAL DATA FOR OXYGEN SAMPLES FROM AIRCRAFT CONVERTERS,
PAGE 5

-SOURCE INFORMATION-

CORPORATE SOURCE -

NAVAL RESEARCH LAB., WASHINGTON, D.C.

REPORT NUMBER -

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OTHER INFORMATION -

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BEHAVIOR OF LIQUID OXYGEN

by

BALIS, E.W.

02/00/57

SECURITY CLASS
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ACCESS LEVEL
NTIS

REPORT CLASS
Incremental

ENTRY EVAL.
Acceptable

-ABSTRACT-

THIS REPORT REVIEWS THE CHEMICAL PROPERTIES OF LIQUID OXYGEN. A LITERATURE SURVEY WAS MADE ON THE REACTIONS OF ORGANIC MATERIALS WITH LIQUID OXYGEN. MUCH OF THE INFORMATION PERTAINS TO THE USE OF ORGANIC MATERIALS WITH LIQUID OXYGEN AS EXPLOSIVES, AND TO THE EXPLOSION HAZARDS OF HYDROCARBONS WITH LIQUID OXYGEN. THE AUTHOR CONCLUDES THAT MOST REDUCING AGENTS AND HYDROCARBONS IN CONTACT WITH LIQUID OXYGEN CONSTITUTE A POTENTIAL EXPLOSIVE SITUATION.

-SOURCE INFORMATION-

CORPORATE SOURCE -

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GENERAL DYNAMICS/CONVAIR

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NEW DATA ON THE EXPLOSIVENESS OF LIQUID OXYGEN AND
HYDRO-CARBONS (RUSSIAN)

by

GITTSEVICH, G.A.
EASYPOV, Z.B.
SAGAIDAK, V.J.

00/00/59

SECURITY CLASS
U/Unrestricted

ACCESS LEVEL
Unlimited

REPORT CLASS
Incremental

ENTRY EVAL.
Acceptable

-ABSTRACT-

EXPERIMENTS SHOWED THAT THE HEATING OF CYLINDER OIL, UNDER PRESSURE IN AIR, PRODUCES LOW-BOILING LIQUID AND GASEOUS HYDROCARBONS AND COKE, THE PRODUCTS OF THERMAL CRACKING. THESE PRODUCTS, MIXED WITH LIQUID OXYGEN, WERE TESTED FOR EXPLOSION SENSITIVITY, AND WERE FOUND TO BE MORE SENSITIVE TO IMPACT THAN NITROGLYCERINE. THE DATA SHOW THAT ACETYLENE SHOULD NOT BE CONSIDERED THE ONLY CAUSE OF EXPLOSIONS IN AIR SEPARATION EQUIPMENT. PRODUCTION OF CRACKING GASES IN RECIPROCATING COMPRESSORS, AND THEIR CONDENSATION WITH OXYGEN IN AIR SEPARATION EQUIPMENT, CAN EXPLAIN EXPLOSIONS IN CASES WHERE ACETYLENE AND LUBRICATING OIL WERE NOT FOUND. CLEANING OF THE PROCESS AIR, WITH REMOVAL OF ALL OILS AND OTHER HYDROCARBONS, CAN INSURE SAFE OPERATION OF AIR SEPARATION EQUIPMENT.

-PERTINENT FIGURES-

TAB.1 COMPOSITION OF GASES OBTAINED BY THERMAL CRACKING OF OIL P-28 AT TEMPERATURES OF 200 AND 350 C, PAGE 14//TAB.2 MINIMUM PRESSURE OF RUPTURE OF DIAPHRAGMS NECESSARY TO PRODUCE EXPLOSIONS IN VARIOUS MIXTURES, PAGE 15

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EXPLOSIONS IN APPARATUSES FOR LIQUEFACTION AND SEPARATION OF AIR,
ZSCHR. F. ANGEW. CHEMIE, 1923, VOL 36, NO. 39-40, P. 262-6

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JOURNAL PROCEEDINGS -

KISLJORD, U.S.S.R. VOL 12, NO. 3, 12-6 (1959) (IN RUSSIAN)

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THE STUDY OF AIR SEPARATION PLANT EXPLOSIONS (JAPANESE)

by

KITAGAWA, T.
ET AL

00/00/64

SECURITY CLASS
U/Unrestricted

ACCESS LEVEL
Unlimited

REPORT CLASS
Summary

ENTRY EVAL.
Good/Excel.

-ABSTRACT-

THIS RATHER EXTENSIVE REPORT GIVES DETAILS OF AIR SEPARATION PLANT ACCIDENTS (EXPLOSIONS) FOR THE PERIOD 1930-1963. 48 ACCIDENTS ARE DETAILED IN ALL. EXTENSIVE TABLES ARE INCLUDED WHICH SUMMARIZE THE DATA IN VARIOUS WAYS. E.G. YEAR, MONTH, LOCATION, TYPE, TYPE OF INDUSTRY, ETC. OF THE 48 ACCIDENTS INCLUDED 37 WERE DIRECTLY INVOLVED WITH AIR SEPARATION PLANTS. THE REPORT ALSO INCLUDES DETAILS OF HAZARDS, EXPLOSION LIMITS, IGNITION SOURCES, ETC. THE REPORT ALSO DISCUSSES THE VARIOUS TYPES OF AIR SEPARATION PLANTS AND GIVES A SUMMARY TABLE OF ALL AIR SEPARATION PLANTS IN JAPAN WITH DETAILS OF SIZE, USER, MAKER AND PURPOSE. THE ONLY HANDICAP TO THIS OTHERWISE FINE REPORT IS THAT IT IS IN JAPANESE.

-PERTINENT FIGURES-

TAB.1 CLASSIFICATION OF ACCIDENTS, PAGE 7//TAB.2 LOCATIONS OF ACCIDENTS, PAGE 7//TAB.3 CLASSIFICATION OF INDUSTRIES IN WHICH ACCIDENTS OCCURRED, PAGE 7//TAB.4 NUMBERS OF ACCIDENTS (1930-1963), PAGE 8//TAB.8 DETAILS OF EXPLOSIONS IN AIR SEPARATION PLANTS, PAGE 9//TAB. AIR SEPARATION PLANTS IN JAPAN AS OF OCTOBER, 1962, PAGE 31

-SOURCE INFORMATION-

JOURNAL PROCEEDINGS -

RYUAN GIJITSU VOL 17, NO. 3, 1-46 (1964)

OTHER INFORMATION -

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LIQUID EXPLOSIVE

by

MCKINLEY, C.

06/07/60

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REPORT CLASS
Summary

ENTRY EVAL.
Good/Excel.

-ABSTRACT-

THIS INVENTION RELATES TO EXPLOSIVES AND MORE PARTICULARLY TO AN EXPLOSIVE SOLUTION COMPRISING FUEL MATERIAL DISSOLVED IN LIQUID OXYGEN. USERS OF OXYGEN AND OTHERS FAMILIAR WITH MANY OF ITS HAZARDS HAVE LONG LOOKED UPON FUEL-OXYGEN MIXTURES AS COMBUSTIONS TO BE AVOIDED WHENEVER POSSIBLE. THE INVENTION DESCRIBED HERE IN CONSIDERABLE DETAIL DEMONSTRATES THAT SOLUTIONS OF FUEL (E.G., METHANE, ETHANE, PROPANE) IN LIQUID OXYGEN CONSTITUTE AN IMPROVED FORM OF EXPLOSIVE THAT CAN BE PREPARED, STORED AND USED IN RELATIVE SAFETY UNDER CERTAIN CONTROLLED CONDITIONS.

-PERTINENT FIGURES-

FIG. 1 DIAGRAMMATIC VIEW OF REFRIGERATED VESSEL CONTAINING SOLUTION OF FUEL IN LIQUID OXYGEN//FIG. 2 DIAGRAMMATIC VIEW OF INSULATED PARTITIONED VESSEL CONTAINING FUEL AND LIQUID OXYGEN IN SEPARATE COMPARTMENTS//FIG. 3 DIAGRAMMATIC VIEW ILLUSTRATING ONE METHOD OF PREPARING, HANDLING, AND STORING A SOLUTION OF FUEL IN LIQUID OXYGEN//FIG. 4 GRAPH OF SOLID-LIQUID EQUILIBRIA FOR METHANE-OXYGEN SYSTEM//FIG. 5 BUBBLE POINT CURVES AT 14.7, 50, 100, AND 200 PSIA FOR THE OXYGEN-ETHANE SYSTEM PLOTTED AGAINST TEMPERATURE, TOGETHER WITH PARTIAL PRESSURE CURVES AT 0.60 AND 2.05 PSI FOR ETHANE//FIG. 6 BUBBLE POINT CURVES AT 14.7, 50, 100, AND 200 PSIA FOR THE OXYGEN-METHANE SYSTEM PLOTTED AGAINST TEMPERATURE, TOGETHER WITH PARTIAL PRESSURE CURVES AT 0.79, 2.7, 5.4, AND 10.8 PSI FOR METHANE

-SOURCE INFORMATION-

REPORT NUMBER -

U.S. PATENT NO. 2,939,778

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ORIGINAL PAGE IS
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HAZARD LEVEL OF HYDROCARBON FILMS IN SYSTEMS CONTAINING
LIQUID AND GASEOUS OXYGEN

by

KEHAT, E.

08/00/61

SECURITY CLASS
U/Unrestricted

ACCESS LEVEL
Unlimited

REPORT CLASS
Summary

ENTRY EVAL.
Good/Excel.

-ABSTRACT-

THE OBJECT OF THIS WORK WAS TO DETERMINE REALISTIC STANDARDS OF CLEANLINESS IN SYSTEMS CONTAINING LIQUID AND GASEOUS OXYGEN. AN ARBITRARY FIGURE OF 4 MILLIGRAMS PER SQUARE FOOT HAD BEEN PREVIOUSLY SET BY EXAMINATION OF SYSTEMS THAT HAD CAUSED NO TROUBLE IN THE PAST. IT WAS FELT THAT THIS FIGURE WAS TOO LOW AND THAT EXPERIMENTAL DETERMINATION OF THE SAFE LEVEL SHOULD BE MADE TO SET SUCH STANDARDS. BASED ON THE EXPERIMENTS REPORTED HERE, THE RECOMMENDED SAFE LEVEL CONTAMINATION WITH HYDROCARBONS WITH VISCOSITY AND VAPOR PRESSURE SIMILAR TO HEXADECANE IS 100 MILLIGRAMS PER SQUARE FOOT.

-PERTINENT FIGURES-

FIG.1 IGNITION APPARATUS USING GASEOUS OXYGEN PAGE 163//FIG.2 IGNITION APPARATUS USING LIQUID OXYGEN PAGE 164//FIG.3 IGNITION APPARATUS USING GASEOUS OXYGEN PAGE 164//FIG.4 IGNITION APPARATUS USING LIQUID OXYGEN BEFORE IGNITION PAGE 165//FIG.5 IGNITION APPARATUS USING LIQUID OXYGEN AFTER IGNITION PAGE 166//FIG.6 UNBURNED HEXADECANE FILM AFTER SPARK IGNITION IN GASEOUS OXYGEN PAGE 166

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J.C. LESUER, AFMND/MTQTP AND C.L. WILLIAMS, STL/PTD, DRAFT OF INTERIOR STANDARDS FOR LOX SYSTEMS, MAY 8, 1959//K.N. PALMER, J. INST. FUEL 29, P. 293 (1956)//I.B. BASVNOV AND V.G. MIKHEDOV, KISLOROD 12, NO. 5, P. 1 (1959). TRANSLATION NO. RD-2220 BY ASSOCIATED TECHNICAL SERVICES, INC.//AIR PRODUCTS, INCORPORATED, UNPUBLISHED WORK//H. BERGER, FEUERSCHUTZECH 21, P. 15 (1941)//D.B. SPALDING, GAS TURBINES - VOL. 2. SOME FUNDAMENTALS OF COMBUSTION. BUTTERWORTHS SCIENTIFIC PUBLICATIONS, LONDON (1955)

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CORPORATE SOURCE -

AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA.
JOURNAL PROCEEDINGS -
ADVANCES IN CRYOG. ENG. VOL 7, 163-9 (1962) (PROC. OF 1961
CRYOG. ENG. CONF., 7TH, ANN ARBOR, MICH., AUG 15-7, 1961)

OTHER INFORMATION -

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III. SAMPLING AND DETECTION LIMITS OF IMPURITIES

keys 187 through 189

DETERMINATION OF ACETYLENE IN LIQUID OXYGEN AND LIQUID
NITROGEN

by

DEE, L.A.

07/18/61

SECURITY CLASS
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ACCESS LEVEL
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REPORT CLASS
Summary

ENTRY EVAL.
Good/Excel.

-ABSTRACT-

AN EVALUATION OF SEVERAL RAPID PROCEDURES FOR DETERMINING ACETYLENE IN LIQUID OXYGEN AND LIQUID NITROGEN IS PRESENTED. IN SEVERAL OF THE PROCEDURES THE ACETYLENE IS LOST WHEN THE INDICATING REAGENTS ARE ADDED. TWO PROCEDURES USING SILICA GEL AS AN ABSORBENT FOR ACETYLENE TO MINIMIZE THIS LOSS ARE DESCRIBED. THESE PROCEDURES ARE SENSITIVE, RAPID, EMPLOY INEXPENSIVE EQUIPMENT AND REQUIRE LITTLE TRAINING TO PERFORM.

-PERTINENT FIGURES-

TAB. 1 ACETYLENE CONCENTRATION PAGE 6

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CORPORATE SOURCE -

AIR FORCE SYSTEMS COMMAND, EDWARDS AFB, CALIF.

REPORT NUMBER -

SSD-TN-61-1//AD-446021

OTHER INFORMATION -

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SAMPLING PROCEDURE FOR LIQUID OXYGEN

by

JOHNS, S.D.

12/31/63

SECURITY CLASS
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NTIS

REPORT CLASS
Summary

ENTRY EVAL.
Acceptable

-ABSTRACT-

THIS IS A PROPOSED STANDARD OPERATING PROCEDURE FOR TAKING SAMPLES FROM LIQUID OXYGEN STORAGE AND TRANSPORT TANKS. THE STANDARD IS TO BE USED BY THE DEPARTMENT OF DEFENSE AND UTILIZES A CRYOGENIC SAMPLER DEVELOPED BY COSMODYNE. A BRIEF REVIEW OF THE HAZARDS ASSOCIATED WITH LIQUID OXYGEN HANDLING IS INCLUDED.

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-SOURCE INFORMATION-

CORPORATE SOURCE -

NORTH AMERICAN AVIATION, INC., DOWNZY, CALIF.

REPORT NUMBER -

QEL-MET-21-123-129//AD-459205

keys 269 through 271

PERMISSIBLE CONTAMINATION LIMITS AND INSPECTION CRITERIA FOR LIQUID OXYGEN, LIQUID NITROGEN, RP-1 FUEL, GASEOUS OXYGEN, GASEOUS NITROGEN, INSTRUMENT AIR AND HELIUM, COMPONENTS AND HANDLING SYSTEMS, REVISION C

-ABSTRACT-

THE PURPOSE OF THE REPORT IS TO PROVIDE A STANDARD EXHIBIT OUTLINING THE CLEANLINESS CRITERIA, AND INSPECTION PROCEDURES, TO ASSURE THE DESIRED CLEANLINESS LEVEL OF COMPONENTS AND SYSTEMS HANDLING LIQUID OXYGEN, LIQUID NITROGEN, GASEOUS NITROGEN, HELIUM AND RP-1 FUEL UTILIZED IN BALLISTIC MISSILES. SPECIFICATIONS, INSPECTION AND CLEANING PROCEDURES AND STANDARDS ARE GIVEN.

-SOURCE INFORMATION-

CORPORATE SOURCE -

BALLISTIC SYSTEMS DIV., NORTON AFB, CALIF.

REPORT NUMBER -

BSD-EXHIBIT-61-3C//AD-615894

keys 281 through 283

GAS-CHROMATOGRAPHIC METHOD FOR THE DETERMINATION OF
POLLUTANTS IN AVIATION LIQUID OXYGEN. (METODO
GASCROMATOGRAFICO PER LA DETERMINAZIONE DEGLI INQUINANTI
NELL'OSSIGENO LIQUIDO AVIO)

by

CIANETTI, E.
PECCI, G.
SCUDERI, G.

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00/00/65

SECURITY CLASS.	ACCESS LEVEL	REPORT CLASS	ENTRY EVAL.
U/Unrestricted	Unlimited	Incremental	Acceptable

-ABSTRACT-

FOLLOWING AN EXPLANATION OF BASIC PRINCIPLES OF GAS CHROMATOGRAPHY AND SOME TOXICOLOGICAL CONSIDERATIONS OF REASONS FOR REDUCING MAXIMUM ALLOWABLE IMPURITIES IN OXYGEN, THE AUTHORS DESCRIBE A METHOD FOR QUICKLY DETERMINING BOTH ORGANIC AND INORGANIC IMPURITIES. ORGANIC IMPURITIES ARE DETERMINED WITH IONIZING FLAME GAS CHROMATOGRAPHY, INORGANIC ONES WITH A THERMISTOR SENSOR, IN TWO OPERATIONS, AFTER PRECONCENTRATION.

-PERTINENT FIGURES-

FIGS. 1 THRU 4 GAS CHROMATOGRAPHY APPARATUS PAGES 30-1,
34-5//FIGS. 5 THRU 13 CHROMATOGRAMS OF IMPURITIES IN OXYGEN PAGES
37-42//TABLE MAXIMUM ALLOWABLE CONTAMINANTS PAGE 32

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PRATIQUE DE CHROMATOGRAPHIE EN PHASE GAZEUSE, MASSON, PARIS, 1964.

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CORPORATE SOURCE -

MINISTERO DELLA DIFESA AERONAUTICA, ITALY

JOURNAL PROCEEDINGS -

RIV. MED. AERONAUT. SPAZ. VOL 28, 26-45 (JAN-MAR 1965)

OTHER INFORMATION -

0020 PAGES, 0013 FIGURES, 0000 TABLES, 0003 REFERENCES

ANALYSIS FOR TRACE HYDROCARBON CONTAMINANTS IN OXYGEN
REBOILERS

by

LINDE, H. W.
SCHMAUCH, G. E.

00/00/66

SECURITY CLASS
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ACCESS LEVEL
Unlimited

REPORT CLASS
Summary

ENTRY EVAL.
Acceptable

-ABSTRACT-

IN CONNECTION WITH A PROGRAM TO STUDY THE CONCENTRATIONS OF HYDROCARBON CONTAMINANTS IN OXYGEN REBOILERS, A GAS CHROMATOGRAPHIC TECHNIQUE WAS DEVELOPED TO MEASURE C(3) THROUGH C(6) HYDROCARBON AT THE 1 TO 15 PART-PER-BILLION LEVEL IN VAPORIZED LOX SAMPLES. THE PROCEDURE CONSISTED OF PASSING A LARGE VOLUME OF OXYGEN (3-15 LITERS) THROUGH A SHORT ALUMINA ADSORPTION COLUMN COOLED TO -78 DEGREES C FOLLOWING WHICH THE ADSORPTION COLUMN WAS SWITCHED INTO A GAS CHROMATOGRAPH CARRIER GAS STREAM. THE COOLANT WAS REMOVED AND THE COLUMN IMMERSSED IN WATER AT 95 DEGREES C. THE HYDROCARBON CONTAMINANTS ELUTED FROM THE ADSORPTION COLUMN WERE CHROMATOGRAPHED ON A 12-FOOT DIBUTYL MALEATE COLUMN AT 40 DEGREES C. A SINGLE ANALYSIS COULD BE PERFORMED IN 30 MINUTES. THE REBOILERS OF FOUR OXYGEN PLANTS WERE SAMPLED AT WEEKLY INTERVALS OVER A SEVERAL MONTH PERIOD. PROPANE WAS REGULARLY FOUND IN CONCENTRATIONS AS HIGH AS 2300 PPB EACH WHILE THE PENTANES AND HEXANES WERE ORDINARILY BELOW THE DETECTABLE LIMITS BUT OCCASIONALLY ROSE TO THE 20 PPB RANGE.

-PERTINENT FIGURES-

FIG.1 MODIFIED GAS CHROMATOGRAPH, PAGE 368//FIG.2 FLOW DIAGRAM, PAGE 368// FIG.3 CHROMATOGRAM OF STANDARD GAS BLEND, PAGE 370//TAB.1 LIMITS OF HYDROCARBON DETECTION, PAGE 369//TAB.2 HYDROCARBONS IN REBOILER LOX, PAGE 371

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-SOURCE INFORMATION-

CORPORATE SOURCE -

AIR PRODUCTS AND CHEMICALS, INC., ALLENTOWN, PA.

JOURNAL PROCEEDINGS -

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SAMPLING AND ANALYSIS OF LIQUID OXYGEN, SUPPLEMENT TO
SUMMARY PROGRESS REPORT NO. 4

by

ENT, W.L.

07/00/60

SECURITY CLASS
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REPORT CLASS
Summary

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Good/Excel.

-ABSTRACT-

THIS SUPPLEMENTAL REPORT TO THE STUDY OF LIQUID OXYGEN CONTAMINATION DISCUSSES THE SAMPLING TECHNIQUES AND ANALYTICAL METHODS WHICH HAVE BEEN USED IN BOTH THE PRODUCTION AND USE OF LIQUID OXYGEN. THE SAMPLING TECHNIQUES AND ANALYTICAL METHODS WHICH ARE NEEDED AND USED HAVE BEEN ESTABLISHED TO MEET THE REQUIREMENTS OF SEVERAL DIFFERENT ASPECTS OF THE PROBLEM, SUCH AS, MONITORING FOR OXYGEN PURITY, MAINTENANCE OF COMBUSTIBLES BELOW DANGEROUS CONCENTRATION LEVELS, CONTROL OF SOLUBLE CONTAMINANTS, AND CONTROL OF SUSPENDED OR CONTAINED SOLID. SAMPLING AND ANALYTICAL TECHNIQUES WHICH ARE THE MOST ACCURATE, SENSITIVE, AND RELIABLE OF THOSE METHODS DISCUSSED, ARE RECOMMENDED. THE RECOMMENDED TECHNIQUES COVER PURITY, TOTAL HYDROCARBON, CARBON DIOXIDE, ACETYLENE, WATER, AND PARTICULATES FOR BOTH PRODUCTION STREAMS, AND LIQUID IN STORAGE.

-PERTINENT FIGURES-

FIG. 1 SAMPLING METHODS, PAGES 11, 12, AND 13//FIG. 2 ORSAT OXYGEN TEST, PAGE 22//FIG. 3 DEW POINT TEMPERATURE OF WATER VAPOR IN AIR, PAGE 29//TAB. 1 SELECTED PHYSICAL-CHEMICAL PROPERTIES OF LIQUID OXYGEN CONTAMINANTS, PAGE 3 //TAB. 2 CO(2) CONTAMINATION STUDY AT MARTIN-DENVER 75 T/D LIQUID OXYGEN FACILITY, PAGE 16//TAB. 3 TYPICAL CONTAMINANT CONCENTRATIONS IN HIGH PURITY LOX, PAGE 26

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AFB, CALIFORNIA, JULY 1960, APPENDIX V//FEDERAL SPECIFICATION
BB-0-925, OXYGEN, 99.5 PERCENT GAS AND LIQUID, SEPTEMBER 16, 1954,
REVISED JUNE, 1957, PARAGRAPH 4.2.3

- SOURCE INFORMATION -

CORPORATE SOURCE -

AIR PRODUCTS, INC., ALLENTOWN, PA.

REPORT NUMBER -

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SPONSOR -

AIR FORCE FLIGHT TEST CENTER, EDWARDS AFB, CALIF.

CONTRACT NUMBER -

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ANALYTICAL AND SAMPLING TECHNIQUES

by

ENT, W.L.

07/00/59

SECURITY CLASS
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ACCESS LEVEL
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REPORT CLASS
Summary

ENTRY EVAL.
Good/Excel.

-ABSTRACT-

VARIOUS INSTRUMENTS FOR AND METHODS OF CONTAMINATION ANALYSIS ARE DESCRIBED. A METHOD OF CONCENTRATING CONTAMINANTS FROM ADSORBENT REGENERATION GAS IS PRESENTED. A TOTAL HYDROCARBON ANALYZER THAT OXIDIZES HYDROCARBONS TO CO(2), WHICH IS THEN SENSED WITH AN INFRARED DETECTOR IS DESCRIBED. A QUICK METHOD OF SPOT CHECKING FOR ACETYLENE CONTAMINATION IN LOX IS DESCRIBED. A FAST, CONTINUOUS FLOW METHOD FOR MEASURING THE SURFACE AREA OF ADSORBENTS IS GIVEN AND AN APPARATUS FOR OBTAINING A REPRESENTATIVE GAS SAMPLE FROM A LIQUID STREAM IS REVIEWED. A DETONATION WHICH OCCURRED IN THE HEAT EXCHANGER OF A HYDROGEN LIQUEFACTION PLANT IS REVIEWED. IT WAS DETERMINED AFTER EXTENSIVE TESTS THAT N(2)O AND NOT CO(2) WAS THE MAJOR CONTAMINANT IN THE HEAT EXCHANGER. FURTHER EXPERIMENTAL TESTS REVEALED THAT N(2)O IS JUST AS GOOD AN OXIDANT AS OXYGEN AND WILL DETONATE WHEN MIXED WITH HYDROGEN IN THE PROPER PROPORTIONS. A SPECIAL CATALYST WAS USED TO CATALYTICALLY CONVERT THE N(2)O TO NITROGEN AND WATER IN A HYDROGEN ATMOSPHERE AND AN INFRARED ANALYZER WAS USED TO DETECT N(2)O IMPURITIES.

-PERTINENT FIGURES-

FIG. 1 FLOW DIAGRAM, HYDROGEN PURIFICATION SYSTEM, PAGE 58//FIG. 2 FLOW DIAGRAM, SAMPLING PROCEDURE, PAGE 59//FIG. 3 FLOW DIAGRAM, CONTAMINANT CONCENTRATION APPARATUS, PAGE 59//FIG. 4 TYPICAL NITROUS OXIDE CONTENT MONITORING CHART FROM INFRARED ANALYZER, PAGE 60//FIG. 5 FLOW DIAGRAM, CONTINUOUS FLOW BRUNAUER-EMMETT-TELLER APPARATUS, PAGE 62//FIG. 6 FLOW DIAGRAM, PORTABLE HYDROCARBON ANALYZER, PAGE 63

-SOURCE INFORMATION-

CORPORATE SOURCE -

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ADSORBER AND DRIER OPERATION AND MAINTENANCE

by

MOODY, E. E.

07/00/59

SECURITY CLASS
U/UnrestrictedACCESS LEVEL
UnlimitedREPORT CLASS
SummaryENTRY EVAL.
Acceptable

-ABSTRACT-

ADSORBENTS ARE NO LONGER USED FOR DRYING APPLICATIONS ONLY, BUT ARE NOW USED EXTENSIVELY FOR SELECTIVELY REMOVING CONTAMINANTS SUCH AS CO(2), NITROGEN COMPOUNDS, AND HYDROCARBONS FROM GAS PROCESS STREAMS. THE ADSORPTION CHARACTERISTICS AND CAPACITIES OF SEVERAL ALUMINA COMPOUNDS ARE DISCUSSED. SILICA GEL IS NORMALLY USED TO ADSORB HYDROCARBONS FROM CRUDE LIX STREAMS. THE ADSORPTION CAPACITY OF SILICA GEL FOR SOME OF THE LIGHTER HYDROCARBONS AT 90 K IS GIVEN. THE DESORPTION CHARACTERISTICS OF THE LIGHTER HYDROCARBONS FROM SILICA GEL ADSORBERS AT VARIOUS TEMPERATURES ARE DISCUSSED. THE OPERATING PRINCIPLES OF OPEN AND CLOSED DRIER REACTIVATION CYCLES ARE DISCUSSED. MANY ASPECTS OF WATER AND HYDROCARBON ADSORPTION AND DESORPTION ARE DISCUSSED AT THE END OF THE ARTICLE. QUESTIONS CONCERNING THE ADSORPTION CHARACTERISTICS OF THE VARIOUS ADSORBENTS, REACTIVATION TEMPERATURES, DEW POINTS FROM DRYERS, ADSORBENT REACTIVATION TIMES, OIL CONTAMINATION, AND ADSORBENT DETERIORATION ARE ANSWERED.

-PERTINENT FIGURES-

FIG.1 DIAGRAM OF AIR SEPARATION CYCLE, PAGE 121//FIG.2 MOISTURE-HOLDING COMPARISON CURVES FOR P-1 AND H-151 ALUMINA, PAGE 122//FIG.3 OPEN DRIER REACTIVATION CYCLE, PAGE 122//FIG.4 CLOSED DRIER REACTIVATION CYCLE, PAGE 123//FIG.5 ADSORPTIVE CAPACITIES, PAGE 124//FIG.6 HYDROCARBON CONTENT OF ADSORBER REACTIVATION GAS, PAGE 124

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AICHE, CINCINNATI, OHIO, DECEMBER, 1958//MCKINLEY, C. AND WANG, E.
S. J., HYDROCARBON-OXYGEN SYSTEMS SOLUBILITY, PRESENTED BY
CRYOGENIC ENGINEERING CONFERENCE, NBS, CAMBRIDGE, MASSACHUSETTS,
SEPTEMBER, 1958

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ANALYSIS OF HYDROCARBON IMPURITIES IN OXYGEN PLANT STREAMS BY GAS CHROMATOGRAPHY

by

PARKS, J. C.
HINKLE, E. A.

00/00/63

SECURITY CLASS
J/Unrestricted

ACCESS LEVEL
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REPORT CLASS
Summary

ENTRY EVAL.
Good/Excel.

-ABSTRACT-

HYDROCARBONS IN GENERAL, AND ACETYLENE IN PARTICULAR, PRESENT A VERY SPECIAL HAZARD WHEN PRESENT AS IMPURITIES AT THE PARTS-PER-MILLION LEVEL IN LIQUID OXYGEN PLANT STREAMS. FOR THIS REASON SOME TYPE OF AUTOMATIC, CONTINUOUS PROCESS INSTRUMENTATION IS DESIRED WHICH SERVES AS A HYDROCARBON MONITOR. ACETYLENE ANALYSIS HAS BEEN ASSIGNED THE HIGHEST PRIORITY IN THIS ARTICLE WHILE THE MONITORING OF OTHER LIGHT HYDROCARBONS IS OF INTEREST PROVIDED THEY ARE READILY DETECTABLE. TWO INSTRUMENT TYPES, PROCESS INFRARED AND PROCESS GAS CHROMATOGRAPHY WITH A HIGH SENSITIVITY DETECTOR, APPEARED ADEQUATE FOR SUCH AN ANALYSIS. AT THE TIME ACTIVE STUDY BEGAN ON THIS APPLICATION CONSIDERABLE WORK HAD BEEN DONE BY VARIOUS INSTRUMENT COMPANIES IN UPGRADING PROCESS INFRARED ANALYZERS TO SUCH A DEGREE THAT THE DESIRED RELIABILITY AND ACETYLENE DETECTION LIMIT COULD BE OBTAINED. WITH ALL THE WORK THAT HAD BEEN DONE, THE BEST OBTAINABLE INFRARED ANALYZER WAS CONSIDERED MARGINAL AT BEST FOR THE PROPOSED APPLICATION. PROCESS CHROMATOGRAPHY WITH A HIGH SENSITIVITY TYPE IONIZATION DETECTOR WAS JUST BECOMING AVAILABLE AS THE STUDY BEGAN. DETECTORS OF THIS TYPE WERE PERFORMING QUITE SATISFACTORILY IN LABORATORY TYPE CHROMATOGRAPHS BUT UNATTENDED CONTINUOUS PROCESS TYPE INSTRUMENT APPLICATIONS WERE BOTH QUITE NEW AND FEW IN NUMBER. HOWEVER, INCREASED SENSITIVITY AND THE ABILITY TO MONITOR MORE THAN A SINGLE COMPONENT WERE TWO FACTORS FAVORING CHROMATOGRAPHY OVER INFRARED ANALYSIS. WHEN A COMMERCIAL PROCESS CHROMATOGRAPH WITH A HYDROGEN FLAME DETECTOR BECAME AVAILABLE ON A CONSIGNMENT BASIS THE DECISION TO USE CHROMATOGRAPHY, AS OPPOSED TO INFRARED, WAS MADE.

-PERTINENT FIGURES-

FIG.1 COLUMN CONFIGURATION FOR SEPARATING DESIRED COMPONENTS, PAGE 33//FIG.2 SECTION OF RECORDER CHART WITH SEVERAL COMPLETE ANALYSES SHOWN, PAGE 33// FIG.3 FRESH AIR FEED SAMPLE SYSTEM, PAGE 34//FIG.4 VAPORIZER DEVELOPED FOR SYSTEM ELIMINATED SAMPLING PROBLEMS, PAGE 35//FIG.5 OVER-ALL LIQUID OXYGEN SAMPLE SYSTEM, PAGE 35.

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PARKS, J. C. AND HINKLE, E. A. A NEW CALIBRATION METHOD FOR
PROCESS GAS CHROMATOGRAPHY, ISA 8TH ANNUAL SYMPOSIUM ON
INSTRUMENTAL METHODS OF ANALYSIS, CHARLESTON, W. VA., APRIL 30 --
MAY 2, 1962

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CORPORATE SOURCE -

MONSANTO CO., TEXAS CITY, TEX.

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ANALYZING LIQUID O(2) FOR CONTAMINANTS

by

MCDONNELL, R.G., JR.
GLASS, J.A.
LAUES, G.W.

00/00/67

SECURITY CLASS
U/Unrestricted

ACCESS LEVEL
Unlimited

REPORT CLASS
Incremental

ENTRY EVAL.
Good/Excel.

-ABSTRACT-

THIS REPORT CONCERNS AN INFRARED METHOD FOR SPOT SAMPLE ANALYSIS OF LIQUID OXYGEN FOR NITROUS OXIDE, CARBON DIOXIDE AND SOME HYDROCARBONS. THE METHOD WAS DEVELOPED TO IDENTIFY AND MEASURE CONTAMINANTS ENTERING AND CONCENTRATING IN AIR SEPARATION PLANTS, IT PROVIDED CLUES WHICH LED TO THE ASSIGNMENT OF CAUSE OF A REBOILER EXPLOSION DUE TO THE DEPOSITION OF CO-CRYSTALS OF NITROUS OXIDE AND ACETYLENE IN LIQUID OXYGEN.

-SOURCE INFORMATION-

CORPORATE SOURCE -

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EVALUATION OF LIQUID OXYGEN SAMPLER (TTU-131/E)

by

MCNAMARA, W.D.

12/00/65

SECURITY CLASS	ACCESS LEVEL	REPORT CLASS	ENTRY EVAL.
C/Confidential	Govt./Contr.	Summary	Poor

-ABSTRACT-

(UNCLASSIFIED) A REPORT OF COMPARISON TESTS BETWEEN U.S. AIR FORCE CRYOGENIC SAMPLERS AP MOD 4 AND TTU 131/E. NINE CONCURRENT SAMPLES WERE TAKEN WITH EACH SAMPLER. IT WAS FOUND THAT THE TTU 131/E WAS A SUPERIOR SAMPLER AND SHOULD BE ADOPTED BY THE CANADIAN AIR FORCE PROVIDED CERTAIN CHANGES ARE MADE IN THE EQUIPMENT AND INSTRUCTIONS.

-PERTINENT FIGURES-

FIG.6-1 CRYOGENIC SAMPLER, TYPE TTU 131/E, EXPLODED VIEW//FIG.5 LIQUID BATCH SAMPLER ASSEMBLY, MODEL 4, EXPLODED VIEW//TAB.1 COMPARISON OF SAMPLER HANDLING CHARACTERISTICS//TAB.2 DISTRIBUTION OF SAMPLES BY LOCATION//TAB.3 RESUME OF LIQUID OXYGEN SAMPLING USING TTU 131/E SAMPLER

-SOURCE INFORMATION-

CORPORATE SOURCE -
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COMPOSITION AND ANALYSIS OF COMMERCIAL LIQUID OXYGEN

by

SMITH, C. P.

00/00/60

SECURITY CLASS
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Unlimited

REPORT CLASS
Summary

ENTRY EVAL.
Good/Excel.

-ABSTRACT-

FOREIGN MATERIALS IN LIQUID OXYGEN NORMALLY COME FROM THE ATMOSPHERE AND FROM THE PRODUCTION PROCESS WHERE IT IS NOT ECONOMICALLY FEASIBLE TO COMPLETELY REMOVE THEM. THIS ARTICLE SETS FORTH THE COMPOSITION OF COMMERCIAL LIQUID OXYGEN AND DESCRIBES METHODS OF PURIFICATION AND ANALYSIS.

-PERTINENT FIGURES-

TAB.2 MAXIMUM LIMITS OF CONTAMINANTS FOR BREATHING OXYGEN LIQUID AND MISSILE PROPELLANT OXYGEN, PAGE 546

-BIBLIOGRAPHY-

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CORPORATE SOURCE -

LINDE CO., TONAWANDA, N.Y.

JOURNAL PROCEEDINGS -

ADVAN. IN CRYOG. ENG. VOL 5, 545-8 (1960) (PROC. OF CRYOG. ENG. CONF., 5TH, BERKELEY, CALIF., SEP 2-4, 1959)

OTHER INFORMATION -

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Keys 5377 through 5379

SAMPLING AND ANALYSIS PROCEDURE FOR DETERMINING LIQUID
OXYGEN CONTAMINATION IN THE JUPITER WEAPONS SYSTEM

by

GORTE, D.A.

KARTI, K.A.

07/26/61

SECURITY CLASS
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NTIS

REPORT CLASS
Summary

ENTRY EVAL.
Acceptable

-ABSTRACT-

PROCEDURES ARE SET FORTH FOR DETERMINING LIQUID OXYGEN (LOX) CONTAMINATION IN THE JUPITER MISSILE WEAPONS SYSTEM. INSTRUCTIONS ARE ESTABLISHED FOR THE QUALITY CONTROL OF LIQUID OXYGEN USED AS A PROPELLANT IN THE SM78 MISSILE.

-SOURCE INFORMATION-

CORPORATE SOURCE -

CRYSLER CORP., DETROIT, MICH.

REPORT NUMBER -

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SPONSOR -

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SAMPLING AND ANALYSIS OF ATMOSPHERIC CONTAMINANTS

by

CONKLE, J.P.

02/00/66

SECURITY CLASS
U/Unrestricted

ACCESS LEVEL
Unlimited

REPORT CLASS
Incremental

ENTRY EVAL.
Good/Excel.

-ABSTRACT-

MEANS OF DETECTION AND QUANTITATION OF CONTAMINANTS IN CLOSED ECOLOGICAL SYSTEMS ARE DISCUSSED. ATMOSPHERIC CONTAMINANTS HAVE BEEN IDENTIFIED, QUANTITATED, AND SUSPECTED FROM STUDIES CONDUCTED ON NUCLEAR SUBMARINES, SPACECRAFT AND SIMULATORS. AT THE USAP SCHOOL OF AEROSPACE MEDICINE, TECHNIQUES HAVE BEEN DEVELOPED FOR SAMPLING AND GROSSLY IDENTIFYING CONTAMINANTS THAT TEND TO OCCUR IN SIMULATORS. THIS INCLUDES SAMPLES OBTAINED NOT ONLY DURING NORMAL CONDITIONS, BUT ALSO DURING ABNORMAL CONDITIONS AS CHARACTERIZED BY A FIRE DURING ONE OF THE EXPERIMENTS. EXPERIMENTAL DATA ARE REPORTED. CONTAMINANT LEVELS ALSO HAVE BEEN EXPLORED IN OTHER GROUND-BASED SIMULATORS. FOR EXAMPLE, ONE EXPERIMENT CONDUCTED AT BOEING WAS TERMINATED DUE TO EXCESS CONTAMINANT LEVELS WHICH PRODUCE PHYSIOLOGICAL ABNORMALITIES. A COMPLETE KNOWLEDGE OF THE CONTAMINANT PROBLEM IS, THEREFORE, IMPORTANT. TO DETERMINE THE TOXICOLOGICAL ASPECTS AND ESTABLISH THRESHOLD LIMIT VALUES (TLV) FOR THE LONG-TERM CLOSED ECOLOGICAL SYSTEM, IT IS NECESSARY TO IDENTIFY AND QUANTITATE THE ATMOSPHERIC CONTAMINANTS WITHIN THE SYSTEM. TECHNIQUES TO OBTAIN SAMPLES WITH SUFFICIENT CONCENTRATION OF CONTAMINANTS TO PERMIT ANALYSIS ARE INCLUDED.

-PERTINENT FIGURES-

TAB.1 COMPOUNDS ISOLATED FROM A SEALED ATMOSPHERE DURING A FIRE, PAGE 255// TAB.2 DISTRIBUTION OF COMPOUNDS BY TRAPPING CYLINDER TEMPERATURE, PAGE 256// TAB.2 RESULTS OF PRELIMINARY EVALUATION, EFFICIENCY AND RECOVERY, PAGE 257// TAB.4 ANIMAL EXPERIMENT CONTAMINANT AND CONCENTRATION AT GROUND LEVEL, PAGE 258//TAB.5 ANIMAL EXPERIMENT CONTAMINANT AND CONCENTRATION AT REDUCED PRESSURE, PAGE 259//FIG.3 ISOLATION SYSTEM FOR MICRO-CONSTITUENTS IN A SEALED ATMOSPHERE, PAGE 261

-SOURCE INFORMATION-

CORPORATE SOURCE -

AEROSPACE MEDICAL DIV., BROOKS AFB, TEX.

REPORT NUMBER -

AD-629622

JOURNAL PROCEEDINGS -

ATMOSPHERIC CONTAMINATION IN CONFINED SPACES CONF., PROC.,
248-267, DAYTON, OHIO, MAR 30-APR 1, 1965

OTHER INFORMATION -

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LIQUID OXYGEN SAMPLER EVALUATION.

by

WRIGHT, E.R.
FERLMAN, M.

12/31/69

SECURITY CLASS
J/OtherACCESS LEVEL
Govt./Contr.REPORT CLASS
SummaryENTRY EVAL.
Acceptable

-ABSTRACT-

A COMPARATIVE ANALYSIS OF NAVY, AIR FORCE AND A RECENTLY DEVELOPED COMMERCIAL LIQUID OXYGEN SAMPLER WAS MADE. EVALUATION OF THE SAMPLERS WAS MADE ON THE BASIS OF EFFICIENCY, RELIABILITY, CONVENIENCE, SAFETY AND COST.

-PERTINENT FIGURES-

TAB.1 TEST RESULTS OF SAMPLING PAGE 7//FIG.1 LIQUID OXYGEN SAMPLING WITH NAVY G-276 SAMPLING SYSTEM PAGE 8//FIG.2 SAMPLER PREPARED FOR SAMPLING PAGE 9//FIG.3 PICTORIAL SCHEMATIC OF CRYOGENIC SAMPLER PAGE 10//FIG.4 SAMPLE BOTTLE PAGE 11//FIG.5 EXTERNAL VIEW OF SAMPLER PAGE 12//FIG.6 BENDIX GU-137-AL SAMPLER AND GU-138-AL CYLINDER PAGE 13//FIG.7 UNDERSIDE VIEW OF GU-137-AL SAMPLER PAGE 14//FIG.8 BENDIX GU-138-AL SAMPLER CYLINDER PAGE 15

-SOURCE INFORMATION-

CORPORATE SOURCE -

NAVAL AIR DEVELOPMENT CENTER, JOHNSVILLE, PA.

REPORT NUMBER -

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OTHER INFORMATION -

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INHOMOGENEITY OF OXYGEN SAMPLES IN THE COSMODYNE CS-4.4
SAMPLER

by

VAN SOMEREN, H.
BECK, H.C.

03/00/68

SECURITY CLASS
U/Other

ACCESS LEVEL
Govt./Ccntr.

REPORT CLASS
Summary

ENTRY EVAL.
Acceptable

-ABSTRACT-

IT WAS FOUND THAT THE DETERMINATION OF CONTAMINANTS IN LIQUID OXYGEN SAMPLES TAKEN WITH THE COSMODYNE CS-4.4 SAMPLER IN SOME INSTANCES GIVES IRREPRODUCIBLE VALUES. THE EFFECT WAS FOUND TO BE DUE TO A FRACTIONATION PROCESS OF THE LIQUID OXYGEN SAMPLE IN THE SAMPLE CUP. AN EXPERIMENTAL CONFIRMATION COULD BE OBTAINED BY DRAWING THE SAMPLE FROM THE COSMODYNE THROUGH ONE OF THE SIDE TUBES. AN ESTIMATE OF THE ERRORS IN THE RESULT OF THE ANALYSES WAS OBTAINED BY CALCULATIONS ON SOME HYPOTHETICAL CASES.

-PERTINENT FIGURES-

TAB.1 ANALYSIS OF SAMPLES, TAKEN VIA DIFFERENT OUTLETS OF THE COSMODYNE, PAGE 3//TAB.2 THE ANALYSIS OF SAMPLES TAKEN FROM THE COSMODYNE UNDER DIFFERENT CONDITIONS, PAGE 4

-SOURCE INFORMATION-

CORPORATE SOURCE -

NATIONAL DEFENSE RESEARCH ORGANIZATION TNO, THE HAGUE,
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REPORT NUMBER -

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HIGH-PURITY PRODUCTS FROM AN AIR SEPARATION PLANT

by

DINAPOLI, R.N.
SASS, A.H.

00/00/70

SECURITY CLASS
U/Unrestricted

ACCESS LEVEL
Unlimited

REPORT CLASS
Summary

ENTRY EVAL.
Acceptable

-ABSTRACT-

THE SIMULTANEOUS PRODUCTION OF HIGH PURITY OXYGEN, NITROGEN, AND ARGON IS OFTEN REQUIRED FROM AIR SEPARATION PLANTS TO MEET TODAY'S NEEDS OF THE MILITARY, SPACE, AND COMMERCIAL MARKETS. DETAILED PRODUCT SPECIFICATIONS AS DEVELOPED BY THE VARIOUS SEGMENTS OF THE INDUSTRY ARE PRESENTED TOGETHER WITH ACTUAL PLANT PERFORMANCE DATA. GAS CHROMATOGRAPHY IS USED TO MEASURE INDIVIDUAL COMPONENT IMPURITIES IN OXYGEN AND TO MONITOR HYDROCARBON CONTENT AT VARIOUS LOCATIONS WITHIN THE PLANT.

-PERTINENT FIGURES-

TAB. 1 TYPICAL HIGH PURITY PRODUCT SPECIFICATIONS PAGE 10//TAB. 3
GAS CHROMATOGRAPHIC ANALYSIS PAGE 12

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FURTHER CONTRIBUTION TO THE DETERMINATION OF POLLUTANTS IN
AVIATION LIQUID OXYGEN.

by

CIANETTI, E.
PECCI, G.

00/00/68

SECURITY CLASS
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ACCESS LEVEL
Unlimited

REPORT CLASS
Summary

ENTRY EVAL.
Acceptable

-ABSTRACT-

REFINEMENTS TO THE GAS CHROMATOGRAPHIC METHOD USED IN THE DETERMINATION OF POLLUTANTS IN AVIATION LIQUID OXYGEN ARE REPORTED. THE REFINEMENTS INVOLVE THE USE OF A COLUMN OF SQUALENE WITH A LENGTH OF 8 M AND A DIAMETER OF 6 TIMES 5 MM FOR ANALYZING ORGANIC POLLUTANTS. THE INNOVATION CONSISTS IN THE FACT THAT AN ANALYSIS MADE ON THIS COLUMN IS FOLLOWED BY ANOTHER ANALYSIS MADE ON ANOTHER COLUMN WHICH IS FILLED WITH FLORISIL AND HAS A LENGTH OF 30 CM AND A DIAMETER OF 6 TIMES 5 MM. THE AMOUNTS OF ACETYLENE AND ETHYLENE THAT CAN BE METERED ARE APPRECIABLY LESS THAN THOSE PERMITTED BY THE ACCEPTANCE SPECIFICATION.

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CORPORATE SOURCE -

AERONAUTICA MILITARE, LABORATORI, DIVISIONE
CHIMICA-TECNOLOGICA, ROME, ITALY.

JOURNAL PROCEEDINGS -

RIV. MED. AERON. SPAZIALE, VOL 31, 99-103 (JAN-MAR 1968).

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CHECK OF OXYGEN PURITY FOR ONBOARD RESPIRATORS BY MEANS OF
IR ABSORPTION SPECTROPHOTOMETRY. (IN ITALIAN).

by

MARANGONI, C.
GIUSTI, A.
DICARLO, E.

00/00/67

SECURITY CLASS
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ACCESS LEVEL
Unlimited

REPORT CLASS
Incremental

ENTRY EVAL.
Acceptable

-ABSTRACT-

DESCRIPTION OF A METHOD FOR METERING THE CARBON TETRACHLORIDE AND TRICHLOROETHYLENE THAT MAY BE PRESENT IN THE LIQUID OXYGEN OF ONBOARD RESPIRATORS BY MEANS OF IR SPECTROPHOTOMETRY. THIS METHOD ALLOWS THE METERING OF THESE TWO COMPOUNDS TO MEET THE REQUIREMENTS OF SPECIFICATION MIL-O-27210-A, AS WELL AS THOSE OF THE ITALIAN AIR FORCE SPECIFICATION AM-M-532.

-PERTINENT FIGURES-

FIG. 1 SYSTEM FOR DIRECT INJECTION PAGE 694//FIG. 2 SYSTEM FOR INJECTION IN OXYGEN FLOW IN A HEATED CHAMBER PAGE 695//FIG. 3 PARTICULARS OF THE CELL ANALYZER PAGE 695//FIG. 4 OXYGEN SPECTRUM WITH IMPURITIES PAGE 697//FIG. 5 SAME AS FIG. 4 EXCEPT WITH CARBON TETRACHLORIDE AND TRICHLOROETHYLENE PAGE 699.

-SOURCE INFORMATION-

CORPORATE SOURCE -

AERONAUTICA MILITARE, LABORATORI, ROME, ITALY.

JOURNAL PROCEEDINGS -

RIV. MED. AERON. SPAZIALE, VOL 30, 693-703 (DEC 1967).

OTHER INFORMATION -

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THE DETERMINATION OF TRACE IMPURITIES IN LIQUID OXYGEN FOR
BREATHING BY INFRA-RED METHODS

by

CORBETT, J.K.

10/00/67

SECURITY CLASS
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ACCESS LEVEL
Govt./Contr.

REPORT CLASS
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ENTRY EVAL.
Good/Excel.

-ABSTRACT-

A DOUBLE-BEAM INFRA-RED SPECTROPHOTOMETER HAS BEEN MODIFIED BY THE ADDITION OF A PAIR OF 40 METRE LONG-PATH CELLS AND ORDINATE SCALE EXPANSION TO MAKE POSSIBLE THE DETECTION AND QUANTITATIVE DETERMINATION OF TRACES OF IMPURITIES IN LIQUID OXYGEN FOR BREATHING. THE EFFECTS OF PRESSURE BROADENING ARE CONSIDERED AND THE LOWER LIMITS OF DETECTION ARE LISTED FOR THE IMPURITIES DETERMINED. THIS SPECTROPHOTOMETER PROVIDES AN ACCURATE AND RAPID METHOD FOR THE DETERMINATION OF THE TRACE IMPURITIES IN LIQUID OXYGEN FOR BREATHING TO AIR STANDARD 14/9A. ONLY INFRARED INACTIVE MOLECULES SUCH AS NITROGEN, HELIUM, ARGON, ETC., ARE INCAPABLE OF DETECTION BY THE METHOD DESCRIBED.

-PERTINENT FIGURES-

TAB.1 SPECTROSCOPIC DATA FOR IMPURITIES, PAGE 4//TAB.2 PRESSURE BROADENING OF A CONSTANT PARTIAL PRESSURE OF ETHYLENE, PAGE 5//TAB.3 PRESSURE SENSITIVITY, PAGE 6//TAB.6 CALIBRATION DATA FOR GASES, PAGE 10//TAB.9 MINIMUM DETECTION LIMITS, PAGE 13//TAB.10 CONCENTRATIONS OF IMPURITIES FOUND IN OXYGEN, PAGE 14

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J. K. CORBETT, INFRA-RED TRACE GAS ANALYSIS. PAPER DELIVERED AT THE CHEMICAL INSPECTORATE, A. D. CONFERENCE, OCTOBER, 1965

-SOURCE INFORMATION-

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AVIATORS BREATHING OXYGEN FROM AIRCRAFT CONVERTERS,
EVALUATION OF

-ABSTRACT-

TWO SAMPLES OF AVIATORS BREATHING OXYGEN WERE ANALYZED FOLLOWING AN ACCIDENT IN WHICH A PILOT WAS KILLED. THE LIQUID OXYGEN HAD BEEN OBTAINED FROM THE AIRCRAFT CARRIER USS BENNINGTON. THE SAMPLES WERE TAKEN FROM LOX CONVERTERS OF AIRCRAFT WHICH HAD OBTAINED LOX FROM THE BENNINGTON AT THE SAME TIME AS THE AIRCRAFT INVOLVED IN THE FATAL CRASH. THE SAMPLES CONTAINED CONTAMINANTS FAR IN EXCESS OF THE MAXIMUMS ALLOWED UNDER SPECIFICATIONS. PILOT COMPLAINTS OF BAD ODORS, HEADACHES, NAUSEA, AND LOSS OF COORDINATION WERE ATTRIBUTED TO THE OXYGEN SUPPLY. IT IS SUGGESTED THAT THE TOXIC EFFECTS OF THE CONTAMINANTS MIGHT BE ENHANCED WHEN BREATHING PURE OXYGEN. IN ADDITION, ONE SAMPLE CONTAINED ACETYLENE IN EXCESS OF ITS SOLUBILITY IN LOX, CONSTITUTING AN EXPLOSIVE HAZARD. THE REPORT RECOMMENDS THAT MEANS OF MONITORING CONTAMINANT LEVELS IN LOX BE PROVIDED TO AIRCRAFT CARRIERS AND ALL LAND-BASED PLANTS WHICH DO NOT HAVE SUCH INSTRUMENTATION. A SUGGESTED INSTRUMENT IS A GAS CHROMATOGRAPH SUCH AS THE NRL TOTAL HYDROCARBON ANALYZER.

-PERTINENT FIGURES-

P&B. ANALYTICAL DATA FOR OXYGEN SAMPLES FROM AIRCRAFT CONVERTERS,
PAGE 5

-SOURCE INFORMATION-

CORPORATE SOURCE -

NAVAL RESEARCH LAB., WASHINGTON, D.C.

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ANALYSIS OF TRACES OF CONTAMINANTS IN BREATHING OXYGEN WITH
A HELIUM DETECTOR AND AN ELECTRON CAPTURE DETECTOR

by

CASTELLO, G.

00/00/71

SECURITY CLASS
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-ABSTRACT-

A METHOD IS DESCRIBED WHICH ALLOWS THE DETERMINATION OF A FEW PARTS PER BILLION OF IMPURITIES IN BREATHING OXYGEN FOR PILOTS AND FOR THERAPEUTIC PURPOSES. FIXED GASES AND CHLORINATED SOLVENTS ARE ANALYSED BY GAS CHROMATOGRAPHY AND DETECTED WITH A HELIUM DETECTOR AND AN ELECTRON CAPTURE DETECTOR, RESPECTIVELY. THE ANALYSIS TIME IS ABOUT 15 MIN. THE PROPOSED METHOD IS SUFFICIENTLY SENSITIVE AND RAPID FOR ROUTINE ANALYSIS OF CONTAMINANTS IN LIQUID OXYGEN TO BE USED FOR BREATHING PURPOSES. THE METHOD CAN BE APPLIED TO THE ANALYSIS OF AIR POLLUTANTS AND TO THE DETERMINATION OF THE PURITY OF GASES.

-PERTINENT FIGURES-

FIG.4 ANALYSIS ON PORAPAK Q COLUMN, STANDARD MIXTURE CONTAINING CH₄, N₂O, ETHANE, ETHYLENE, ACETYLENE AND PROPANE, PAGE 121//FIG.5 CALIBRATION CURVES OBTAINED WITH THE EXPONENTIAL DILUTION FLASK, PAGE 122// FIG.6 ANALYSIS OF CHLORINATED COMPOUNDS ON AN APIZZON L COLUMN WITH ECD, PAGE 123//TAB.2 MAXIMUM ALLOWED CONCENTRATION VALUES OF CONTAMINANTS IN BREATHING OXYGEN FOR PILOTS, PAGE 118//TAB.3 SENSITIVITY OF HELIUM DETECTOR TO CONTAMINANTS, PAGE 123//TAB.5 PRACTICAL LIMIT OF DETECTION AT MAXIMUM SENSITIVITY FOR 1 ML. OF SAMPLE AT ATMOSPHERIC PRESSURE, PAGE 124

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-SOURCE INFORMATION-

CORPORATE SOURCE -

GENOA UNIV., ITALY. ISTITUTO DI CHIMICA INDUSTRIALE

JOURNAL PROCEEDINGS -

J. CHROMATOGR. VOL 58, NO. 1, 117-25 (1971)

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CONTAMINATION SENSORS

by

ANTHONY, H.V.
CREW, J.G.
LARUE, E.P.
MCDONALD, J.P.
PICCONE, M.

09/12/67

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-ABSTRACT-

THIS PAPER PRESENTS THE RESULTS OF A NASA-SPONSORED STUDY, COMPLETED IN APRIL 1966, INTENDED TO PROVIDE A BASIS FOR POSSIBLE EVENTUAL USE OF AUTOMATIC CONTAMINATION SENSORS AND MONITORS CAPABLE OF BEING INSTALLED IN A FLUID SYSTEM, AND OF REMOTELY INDICATING PARTICLE-CONTAMINATION COUNT, AMOUNT OF MOISTURE PRESENT, PURITY OF THE FLUID, OR SOME COMBINATION OF THESE. SOME INFORMATION CONCERNING MECHANICAL SAMPLING IS ALSO INCLUDED.

-SOURCE INFORMATION-

CORPORATE SOURCE -

MARTIN MARIETTA CORP., DENVER, COLO.

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JOURNAL PROCEEDINGS -

CURRENT AND ADVANCED CONCEPTS IN INSTRUMENTATION AND AUTOMATION, AEC/NASA CONTAMINATION CONTROL SYMP., PROC., 45-62, ALBUQUERQUE, N. MEX., SEP 12-4, 1967

OTHER INFORMATION -

0018 PAGES, 0012 FIGURES, 0000 TABLES, 0003 REFERENCES

A STUDY OF TRACE IMPURITIES IN AVIATORS BREATHING OXYGEN

by

DREW, C.M.
SCHOWEN, P.L.
SMITH, S.R.

02/03/58

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-ABSTRACT-

A STUDY OF AVIATORS BREATHING OXYGEN FROM PRESSURE AND LIQUID APPARATUS HAS BEEN CARRIED OUT TO DETERMINE THE IMPURITIES THAT ARE RESPONSIBLE FOR NAUSEA AND ANOXIATION REPORTED BY SOME PILOTS. AN ANALYTICAL METHOD USING GAS CHROMATOGRAPHY AND MASS SPECTROMETRY HAS BEEN USED TO DETERMINE THE IDENTITY AND CONCENTRATION OF THE CONTAMINANTS IN THE BREATHING OXYGEN. A POSSIBLE MECHANISM WHEREBY THESE CONTAMINANTS AFFECT THE PILOTS HAS BEEN PROPOSED AND RECOMMENDATIONS TO PURIFY THE BREATHING OXYGEN HAVE BEEN MADE. THE REPORT CONCLUDES WITH A NUMBER OF RECOMMENDATIONS MOSTLY CENTERING AROUND PURGING OF THE STORAGE TANKS, TRANSFER CARDS AND MOST ESPECIALLY THE CONVERTER TANKS IN THE AIRCRAFT. THE USE OF ABSORBENTS IN THE LOW PRESSURE FEED LINES IN THE AIRCRAFT IS ALSO RECOMMENDED.

-PERTINENT FIGURES-

FIG. 2 RUN NO. 501 LIQUID OXYGEN FROM CONVERTER, PAGE 13//FIG. 3 RUN NO. 503 STORAGE TANK NO. 1, PAGE 14//FIG. 4 RUN NO. 504 GAS FROM CONVERTER, PAGE 15//FIG. 7 RUN NO. 507 NEWLY REILLED STORAGE TANK, PAGE 18//FIG. 8 RUN NO. 508 OXYGEN LIQUEFIED FROM CYLINDER, PAGE 19//TAB. 1 ANALYSIS OF OXYGEN SAMPLES, PAGES 24-26

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DREW, CHARLES M., JAMES R. MCNESBY, S. RUVEN SMITH AND ALVIN S. GORDON. APPLICATION OF VAPOR PHASE CHROMATOGRAPHY TO MASS SPECTROMETER ANALYSIS, ANAL CHEM, VOL. 28, (1956) P. 979//DREW, CHARLES M., AND JAMES R. MCNESBY. SOME PROBLEMS ENCOUNTERED IN THE APPLICATION OF VAPOR PHASE CHROMATOGRAPHY TO KINETIC STUDIES. VAPOR PHASE CHROMATOGRAPHY SYMPOSIUM BRITISH INST. PET., LONDON. MAY-JUNE 1956. BUTTERWORTHS SCI. PUB. 1957//EGGERTSON, F. T., H. S. KNIGHT AND SIGURD GROENINGS. GAS CHROMATOGRAPHY, USE OF LIQUID MODIFIED SOLID ADSORBENT TO RESOLVE C(5) AND C(6) SATURATES, ANAL CHEM, VOL. 28 (1956), P. 303//KOBAYASHI, YOSHITAKA, AND TETSUGO KATAGAWA, (YOKAHAMA NATL UNIV.), RAPID METHOD FOR THE

DETERMINATION OF LOW CONCENTRATIONS OF NO(2) IN LIQUID OXYGEN IN
AIR SEPARATION, J CHEM SOC JAP, IND. CHEM. SECT., VOL. 58, (1955),
PP. 651-654//FAIRHALL, LAWRENCE T., INDUSTRIAL TOXICOLOGY, 2ND
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HANDBOOK OF DANGEROUS MATERIALS, REINHOLD PUBLISHING CORP., (1951)

- SOURCE INFORMATION -

CORPORATE SOURCE -

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DEPT.

REPORT NUMBER -

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AVOID MISLEADING ANALYSES

by

FALL, W.L.

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ENTRY EVAL.
Acceptable

-ABSTRACT-

AIR PRODUCTS DISCOVERED THAT LIQUID OXYGEN TESTED FOR PRESENCE OF ACETYLENE BY THE ILLOSVEY SOLUTION SHOWED NO ACETYLENE, WHILE IN REALITY IT CONTAINED 1 TO 1.5 PPM ACETYLENE. CONCURRENT WITH THIS THE SAMPLES SHOWED THE PRESENCE OF CARBON DIOXIDE IN EXCESS OF ITS SOLUBILITY LIMIT. IT WAS POSTULATED THAT THE ACETYLENE WAS ABSORBED BY THE SOLID CARBON DIOXIDE. PROOF OF THE LATTER HAS NOT BEEN FOUND BUT ONE CAN STATE THAT THE PRESENCE OF EXCESS CARBON DIOXIDE SOMEHOW MASKS THE PRESENCE OF ACETYLENE.

-SOURCE INFORMATION-

CORPORATE SOURCE -

AIR PRODUCTS AND CHEMICAL, INC., ALLENTOWN, PA.

JOURNAL PROCEEDINGS -

SAFETY IN AIR AND AMMONIA PLANTS VOL 11, 50 (1969) (PRES. AT AIR AND AMMONIA PLANT SAFETY SYMP., MONTREAL, CANADA, 1968)

PUBLISHER -

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CONTAMINANT DETECTOR FOR AVIATORS BREATHING OXYGEN

by

MILLER, R.L.
ROBINSON, C.E.
JAKELS, K.G.

05/00/72

SECURITY CLASS	ACCESS LEVEL	REPORT CLASS	ENTRY EVAL.
U/Unrestricted	Unlimited	Summary	Acceptable

-ABSTRACT-

THIS PAPER IS CONCERNED WITH FINDING A PORTABLE OXYGEN ANALYZER WHICH WILL PERMIT THE DETECTION OF CONTAMINANTS AT OR BELOW ALLOWABLE LEVELS. THIS IS NEEDED TO INVESTIGATE PHYSIOLOGICAL INCIDENTS INVOLVING AIRCRAFT CREWS WHERE CONTAMINATION OF THE BREATHING OXYGEN SUPPLY IS SUSPECTED. THE ANALYSES ARE CURRENTLY DONE AT REGIONAL LABORATORIES WHERE TIME DELAYS AND SAMPLING TECHNIQUES HAMPER INVESTIGATIONS. DISCUSSION OF THE ANALYTICAL REQUIREMENTS AND DEVELOPMENT OF AN AVIATORS BREATHING OXYGEN ANALYZER AND CONTAMINANT DETECTOR. TWO APPROACHES CURRENTLY UNDER DEVELOPMENT ARE DESCRIBED. ONE APPROACH IS BASED ON GAS CHROMATOGRAPHY AND THE OTHER ON THE USE OF A COMMERCIALY DEVELOPED PORTABLE INFRARED ANALYZER. THE AUTHORS PROPOSE A SIX MONTHS TEST OF THE TWO INSTRUMENTS TO MAKE A DECISION REGARDING THE BEST APPROACH.

-PERTINENT FIGURES-

TAB. 1 ALLOWABLE CONSTITUENTS IN AVIATORS BREATHING OXYGEN, PAGE 7

-BIBLIOGRAPHY-

CASTELLO, G., ANALYSIS OF TRACES OF CONTAMINANTS IN BREATHING OXYGEN WITH A HELIUM DETECTOR AND AN ELECTRON CAPTURE DETECTOR, J. CHROMATOGRAPHY 58, 117-125 (1971)

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CORPORATE SOURCE -

SCHOOL OF AEROSPACE MEDICINE, BROOKS AFB, TEX.

REPORT NUMBER -

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THE DETERMINATION OF HYDROCARBON TRACES IN ATMOSPHERIC AIR
AND LIQUID OXYGEN

by

THEER, J.

02/27/63

SECURITY CLASS
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REPORT CLASS
Summary

ENTRY EVAL.
Good/Excel.

-ABSTRACT-

FOR A LONG TIME A RAPID METHOD OF DETERMINING TRACES OF HYDROCARBONS IN THE AIR SUCKED INTO AND THE LIQUID OXYGEN PRODUCT OF AIR SEPARATION PLANTS HAS BEEN SOUGHT. THIS IS NEEDED TO AVOID DANGERS OF EXPLOSIONS DUE TO THE ACCUMULATION OF HYDROCARBONS ESPECIALLY ACETYLENE. THIS PAPER DESCRIBES A GAS CHROMATOGRAPH WITH A MICROFLAME IONIZATION DETECTOR. A 10 ML SAMPLE CAN BE PROCESSED IN 5 MINUTES WITH A SENSITIVITY OF 5 PARTS PER MILLION AND IN 15 MINUTES A SENSITIVITY OF 10 PARTS PER BILLION CAN BE ACHIEVED. THE SAMPLER AND INSTRUMENT HAVE BEEN TESTED IN CONTINUOUS OPERATION.

-PERTINENT FIGURES-

TAB. P. 6 HYDROCARBON CONTENT OF ATMOSPHERIC AIR FROM VARIOUS REGIONS OF GERMAN DEMOCRATIC REPUBLIC//FIG. 3 HYDROCARBON CHROMATOGRAM FOR LIQUID OXYGEN, PAGE 7//FIG. 4 CONCENTRATION APPARATUS FOR HYDROCARBONS FROM ATMOSPHERIC AIR, PAGE 8//FIG. 5 HYDROCARBON CHROMATOGRAM FOR ATMOSPHERIC AIR, PAGE 7

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SCHUSTER. GASFORMIGE BRENNSTOFFE. VOL 2//HOLZHAUSER, H., GASCHROMATOGRAPHIE 1959, MATERIAL ZUM 2. SYMPOSIUM UBER GASCHROMATOGRAPHIE IN BOHLEN 1959, P. 143//HABLEY, J., NATURE 181, 178 (1958)//KAISER, R., GASCHROMATOGRAPHIE LEIPZIG 1960, P. 97//DESTY, D. H., GASCHROMATOGRAPHIE, LONDON 1958, P. 142//FRENZEL, J., GASCHROMATOGRAPHIE 1959, MATERIAL ZUM 2. SYMPOSIUM UBER GASCHROMATOGRAPHIE IN BOHLEN 1959, P. 109

-SOURCE INFORMATION-

CORPORATE SOURCE -

INSTITUTE FOR CHEMICAL AND REFRIGERATING EQUIPMENT, DRESDEN,
EAST GERMANY
REPORT NUMBER -

N64-22627//FTD-IT-62-1665//AD-401389
JOURNAL PROCEEDINGS -
CHEM. TECH. (LEIPZIG), NO. 3, 164-7 (1962) (TRANSL. BY
FOREIGN TECHNOLOGY DIV., WRIGHT-PATTERSON AFB, OHIO)
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ANALYTICAL METHODS FOR LIQUID OXYGEN

by

SMITH, C.P.

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Unlimited

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Summary

ENTRY EVAL.
Acceptable

-ABSTRACT-

LIQUID OXYGEN ANALYSES ARE CUSTOMARILY MADE FOR PROCESS CONTROL, PRODUCT PURITY AND TO AVOID HAZARDS. USUALLY ANALYTICAL INFORMATION REQUIRED FOR PROCESS CONTROL IS NOT EXTENSIVE. USE OF MODIFIED ORSAT APPARATUS FOR MANUAL DETERMINATION OF THE OXYGEN CONTENTS OF VARIOUS LIQUID SAMPLES IS ROUTINE IN MOST PLANTS. IN ADDITION TO THE ABOVE GENERAL METHOD THE AUTHOR REVIEWS METHODS FOR DETERMINING OTHER IMPURITIES SUCH AS CARBON DIOXIDE (INFRARED TECHNIQUES), ACETYLENE (ILLOSVAI METHOD), HYDROCARBONS (CHEMICAL METHODS), SOLID MATTER (FILTERS) AND WATER. THE AUTHOR SPECIFICALLY DISCUSSES ORGANIC TRACE CONTAMINANTS IN BREATHING OXYGEN SUPPLIES FOR AIRCRAFT.

-SOURCE INFORMATION-

CORPORATE SOURCE -

UNION CARBIDE CORP., TONAWANDA, N.Y.

JOURNAL PROCEEDINGS -

ADVAN. CRYOG. ENG. VOL 4, 436-42 (1960) (PROG. OF CRYOGENIC ENGINEERING CONF., 4TH, CAMBRIDGE, MASS., SEP 3-5, 1958. PAPER G-4)

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PRODUCTION CONTROL OF LIQUID OXYGEN AT COMMERCIAL
FACILITIES

by

SMITH, C.P.

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REPORT CLASS
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-ABSTRACT-

THIS IS A SHORT SUMMARY PAPER CONCERNING PRODUCTION CONTROL IN
COMMERCIAL AIR SEPARATION PLANTS. INCLUDED ARE SECTIONS ON HAZARD
CONTROL, PRODUCTION CONTROL FOR EFFICIENCY, PRODUCTION CONTROL FOR
QUALITY, PRODUCT HANDLING AND PRODUCT ANALYSIS.

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SAFETY IN AIR AND AMMONIA PLANTS, VOLUMES 1 THROUGH 5, PUBLISHED
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STREET, NEW YORK 17, NEW YORK

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LIQUID MISSILE PROPELLANTS SYMP., 2ND, HERSHEY, PA., NOV 3-5,
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